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THE RENAISSANCE OF SCIENCE.

BY DR. EDWARD S. HOLDEN,

U. S. MILITARY ACADEMY, WEST POINT, N. Y.

THE centuries immediately following the disruption of the Roman empire witnessed the formation of the languages of southern Europe—Italian, Spanish, French—and the process of their building-up placed an almost insuperable barrier in the way of the advancement of learning. Latin became a dead language; Greek was entirely unknown; the spoken languages were never written. 'The whole treasury of knowledge was locked up from the eyes of the people.' All legal documents and all correspondence as well as all the rituals of the church were couched in Latin, and until the end of the thirteenth century it was very unusual for a layman to write or even to read. The clergy were the only clerks. It is disputed whether Charlemagne could sign his name, and it is certain that Alfred the Great had but an indifferent knowledge of Latin. From the sixth to the eleventh century the mass of the clergy were only slightly more enlightened. Alfred declares that at the date of his accession (871) he did not know a single priest south of the Thames who understood the ordinary prayers of the church, or who could translate Latin into his mother tongue. The ignorance of the dark ages in Europe is a direct consequence of the confusion of tongues.

Through the translations of Nestorian monks in the orient the works of Greek philosophers, physicians, mathematicians and astronomers became known to the Arabs in the eighth and ninth centuries. The precepts of Ptolemy were followed closely, even slavishly, by the astronomers of Bagdad, Persia, Egypt, Spain and Turkistan, so long as learning lasted in these lands. We owe an immense debt to the Arabs for their faithful transmission of astronomical theories which they had

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not sufficient mathematical genius to greatly improve; for thousands of observations made to increase the accuracy of the tables of the motions of the sun and planets; for catalogues of the position and brilliancy of the fixed stars; and last and not least, for keeping the lamp of learning burning in their great schools, or universities, in Spain and elsewhere during the centuries from the eighth to the fifteenth. Since the time of the Greek schools of Alexandria the home of the exact sciences has been successively in Bagdad, Cordova, Seville, Tangiers, Bokhara and Samarkand. It was only in the sixteenth century that they were firmly domiciled in christian Europe.

Even in the shortest sketch it is necessary to point out that a great part of the astronomical learning of the Moorish schools was due to Jews; and that it is to orientals and not to Europeans that we owe the earliest recognition of the fundamental truth that all sound progress in astronomy must be based on actual and continued observation of the places of the heavenly bodies; that theory must be based upon practise. It is usual to credit this insight to Tycho Brahe, and it is certain that his greatest claim to our gratitude is based upon a thorough recognition of the fact that until observations have shown us exactly how the planets move we can form no adequate theories to account for their motions. But the astronomers of India and Persia in the ninth and tenth centuries thoroughly understood this fundamental notion, as did Ulugh Beg (1393–1449) at Samarkand, and they invented means to obtain observations of adequate accuracy and in sufficient number.

The need for more observations and for greater precision was also fully realized by Purbach as early as 1450. Regiomontanus returned from Italy in 1471 to set up in Nuremberg an observatory for the especial purpose of correcting the Alphonsine tables, which Purbach and himself had found to be so defective a score of years earlier. Landgrave Wilhelm IV of Cassel and his astronomers were working in the same direction in Tycho's time. It is Tycho's merit that he was the first in Europe to create instruments of sufficient power, and to use them with exceeding diligence over a long series of years. There was little knowledge in Denmark of what was doing in the orient. Tycho's plans were made quite independently of the further east. At the same time Europe touched the orient closely, through Venice, and sent many of her sons to study at Moorish schools; and it is not conceivable that Tycho was entirely ignorant of the details of the work done, a century and a half before his time, in Samarkand.

The debt of Europe to the remoter east has never yet been fully reckoned out. For thirty centuries the culture of the orient has, in one way or another, created, informed or modified our own. The religion, the learning, the art, the architecture of the east have most

intimately influenced the west. The chivalry of Europe is, in great measure, a product of the Saracen chivalry which entered Europe in two streams flowing through Constantinople and through Spain. The poetry of the Troubadours and the romances of the feudal period are directly derived from the Arabs. Even the rhythms of the Troubadours are copied from Arab models, and the three-stringed lyre of the Jongleur is from an Arab original. It is from the east that the very idea of rhymed poetry is derived. To speak only of Persia: Alexander the Great destroyed at Persepolis buildings more magnificent than any others ever seen on the round world, not excepting the monuments of Athens; the looms of Persia made imperial Constantinople splendid; chemistry is a Persian word, and the Arabs borrowed their knowledge of the art from Iran; all the drugs of Hippocrates have Persian names; the Persians transmitted the immortal fables and apologues of India to the Arabs, and through them to the west; the works of the Persian sage Avicenna were text-books in the universities of Paris and Montpellier as late as the time of Louis the Fourteenth; our little children are bred up on the tales of the Arabian Nights, a great part of which are of Persian origin; in a thousand unacknowledged ways the west has been taught by the east. When England was a wilderness, inhabited by savages, Persia was polite, cultivated, ingenious, learned and illustrious. Whether we know it or not, we have learned much from them, though the debt is all but ignored except in the writings of scholars.

Moslems took the alien culture of the Greeks much as the Japanese of our own time have taken the culture of Europe. I remember well handing an astrolabe made in England in the seventeenth century, for one of the ships of the Alaskan fleet of Russia, to an accomplished officer of the Japanese navy. He was perfectly familiar with modern navigation and with the sextant, but this classic instrument was a complete puzzle to his mind. The contemporaries of his father had sailed their little boats by timid coasting from headland to headland of the Inland Sea; but no one of them had ever seen a sextant or a quadrant. Like the Arabs of long ago they made one leap from complete ignorance of such matters to the possession of the most refined apparatus, while English navigators, our ancestors, slowly mastered the use of the backstaff, the cross-staff, the astrolabe, the quadrant, the sextant, during a long succession of centuries.

Such considerations as these partly account for the fact that, in spite of their wonderful acumen, the Arabs added little or nothing to the theory of scientific astronomy. Moreover, their religion allowed them but scant liberty. They were confined within the narrow limits of Koranic permissions and prohibitions. It was forbidden to make an image of any living thing either by painting or sculpture. Poetry was

discouraged by the traditions of Mohammed. Architecture was the only outlet for their artistic impulse. They could not dissect the human body. Original investigation was closed on nearly every side. What they were permitted to do, they did well. In astronomy they preserved the classic books and they made many precise observations. It is almost an accident that so little use was made of their work by Europeans. If there had been an active commerce between the east and all the countries of the west the history of Europe in the middle ages would have been changed and brightened.

The scientific history of the middle ages is sharply divided into two periods. In the first, no part of Arabic learning had penetrated the west. All knowledge came from the Greeks through the Romans. In the second, the treasures of the Greeks were made known together with the results of three centuries of acute commentary by the subtle-minded philosophers of the east. The astronomy of the first period was represented by Manilius, Hyginus and Bede. The works of Ptolemy were unknown. These were indeed dark ages for science. In the second, all the wealth of Alexandria was opened, and it was increased by the observations of Albategnius and Ibn Yunos and the commentaries of Albumasar and his successors.

A satisfactory history of science in the middle ages is still a desideratum. Such a book could not possibly have been written before 1860, for the doctrine of special creations would then have assumed the place of the doctrine of a slow, steady and continuous evolution. Episodes of decadence are as much a part of evolution as examples of advancement. The book might well be written as a series of biographies of great men, if this were done without forgetting that, in the strictest sense, every man, even the greatest, is the product of his time.

With the advent of the christian religion theology had become the supreme science of the west. In theory, at least, the whole of philosophy could be deduced from revelation, and at all events theology was the standard to which all philosophizing was obliged to conform. Just as philosophy could be got, by deductive reasoning, from theology, so the whole of science could be deduced from a few fundamental facts, precisely as the whole of geometry of the ancients was derived from a few axioms. Under pre-suppositions of this sort, there could be no natural science, since our very conception of science implies theory compared with, and controlled by, observation and experiment. The method of medieval science was logical deduction. The method of modern science is a very different thing.

'Thus,' as Whewell formulates it:

A universal science was established with the authority of a religious creed. Its universality rested on erroneous views of the relations of words and truths; its pretensions as a science were admitted by the servile temper of men's

intellects; and its religious authority was assigned to it by making all truth a part of religion. And as Religion claimed assent within her own jurisdiction under the most solemn and imperative sanctions, Philosophy shared in her imperial power, and dissent from their doctrines was no longer blameless or allowable. Error became wicked, dissent became heresy; to reject received human doctrines was nearly the same as to doubt Divine declarations.

Aristotle became the sole authority in science, just as the church was the sole authority in religion.

While a general statement like the foregoing is, in the main, true, it requires countless modifications if it is to be taken as an explanation of the course of intellectual progress in the middle ages. Their conditions were almost as complex as those that surround our own century. They were modified by unnumbered circumstances of place, time and personality. No one formula can possibly express the spirit of the middle ages, even in respect of a single branch of science. It is, for example, entirely true that the authority of Aristotle was overwhelming. What was not found in his works was, necessarily, false. This is a general truth, and the career of Galileo is a commentary upon it. On the other hand, it must not be supposed that Aristotle was always and everywhere unquestioned.

It was not until two great doctors of the church—Albertus Magnus and St. Thomas Aquinas—had adopted, explained and consecrated Aristotle's doctrines in the thirteenth century that his authority became overpowering and universal. Roger Bacon, the great contemporary of St. Thomas and Albert, was also, as Voltaire has said, "un homme admirable pour son siècle. Quel siècle? me direz-vous. C'était celui du gouvernement féodal et des scholastiques. Figurez vous les Samoïdes et les Ostiasques qui aurient lu Aristote et Avicenne—voilà ce que nous étions."

In the year 1000, the world did not come to an end, as had been prophesied and expected: 'Whereupon men took renewed possession of the Earth and of themselves.' This gave leisure to the spirit; leisure and comfort for the body had already, in some measure, been conquered. Men again began to be curious regarding humanity, life, nature. Science for the first time became possible. It is with the greatest difficulty that the attitude of the middle ages towards scientific matters can be comprehended. The time is full of the sharpest contrasts. Roger Bacon illustrates its highest lights. Its deepest shadows are found in the doings of the inquisitors of Spain. Its everyday aspect is, perhaps, best to be conceived from poems and legends that pleased the people. *Bestiaries,* or story-books of animals, were extremely popular.

They declared, among other things, that:

The basilisk kills with a glance of his eye; "the bite of the cockatrice is fatal to the weasel if the weasel eat not rue before"; the salamander lives in fire;

the mandrake groans when pulled from the ground; the pelican in her piety feeds her brood by blood plucked from her breast; the barnacle is half herb, half animal; the hyena converses with shepherds; the crocodile weeps over his victims; the barometz is a lamb that is also partly a vegetable; the fleeing lion erases his tracks with the end of his tail; the father of the ant-lion "hath a shape like a lion, his mother that of an ant; the father liveth on flesh and the mother on herbs; his fore-part is like that of a lion and his hind-part like that of an ant; being thus composed he is neither able to eat flesh like his father, or herbs like his mother, and so he perisheth."

These are a few extracts from the story books that delighted Europe for centuries.

The earth was generally believed to be flat, though the Greeks of Alexandria knew better. The 'waters above the firmament' were navigable; and there was a story of an anchor dropped to earth from a ship sailing in this second ocean. There were races of men with one eye, others with one leg, others whose enormous feet served as umbrellas to keep away the rays of the torrid sun. Shakespeare's 'men whose heads do lie between their shoulders' date from these legends. Fauns, fairies, lamiæ, sylphs, vampires and the like were dreaded. Everything was received with acquiescent wonder, and without criticism, whether it were a miracle done by the relic of a saint, or the extravagant tale of a traveler. The age of faith deserves its name in so far as it was characteristically an age devoid of criticism.

An Arabic compilation of the tenth century, *Adja ib al-Hind*—the marvels of India—is composed of a hundred and twenty-four paragraphs, each relating to some wonder recounted to the author by persons whom he names. The work is entirely serious and the narrators were famous seamen, merchants and travelers who were familiar with the Indian Ocean, the Malay archipelago, the China seas and Ceylon. These stories taken as a whole exhibit the extensive commerce carried on, even at that day, between the nearer and the farther east, and speak eloquently for the skill and courage of those early navigators who traversed almost unknown seas with nothing but the stars to guide them. Many of the marvels of the Arabian Nights are to be found here—the *roc,* the valley of diamonds guarded by serpents, the shipmen who mistake the back of a sleeping turtle of gigantic size for an island, and the like. The legend of the Island of Women, under the star *Canopus,* where the sea slopes downward, and where only women dwell, is gravely given without even the phrase 'But Allah alone knows if this be true,' by which a good Muslim shows his doubts. Of the existence of the gigantic bird, the *roc,* the author says 'This is a fact well known to shipmen, and I have never known any one to doubt it.' The crocodiles of the Harbor of Serira do not bite men, he says, because they were enchanted by a magician who had the power to make them harmless and harmful at will. The prudent king of the country caused

them to be made harmless—and then slew the magician; so that to this day the water is safe. Stories of this sort are interwoven with admirably intelligent accounts of these distant countries. All are equally credited and credible.

What strikes a modern reader with astonishment is by no means the ignorance of the writer, but rather his entire lack of the critical faculty. This lack, for Europeans as well as for Arabs, may be taken as characteristic of the middle ages. Our ancestors appear, at times, nothing but adventurous Eskimo who had read Aristotle.

In the year 1238 the inhabitants of Sweden were prevented by their fear of the Tartars, from sending as usual, their ships to the herring fishery on the coast of England; and as there was no exportation, forty or fifty of these fish sold for a shilling. "It is whimsical enough," says Gibbon, "that the orders of a Mogul Khan, who reigned on the borders of China, should have lowered the price of herrings in the English market."

The reign of Faith appears, at first glance, so absolute during the Middle Ages, that one is tempted to believe that for a thousand years no voice was lifted against established religion. A study of the details of history brings, however, many episodes to light that exhibit something like a continuous change from the rationalism of the ancients to that of the moderns. The chain is easiest to trace, of course, in the history of philosophy. It existed likewise in the history of science. The whole of the thirteenth century, exclusively religious as it appears at first sight, was stirred by an undercurrent of free inquiry which has left little trace in written history solely because the history of that period was written by the Dominican school. Roger Bacon was a product of his age, then, not a *lusus naturæ*.

The philosophy of the Arab commentators of Aristotle—pantheistic in its essence—was utterly opposed to the philosophy of orthodox scholastics. In the year 1209 the council of Paris condemned the *Natural Philosophy* of Aristotle and its commentaries. A bull of Gregory IX. in 1231 confirmed the condemnation. Such condemnations demonstrated the prevalence of presumed error. By the middle of the century Albertus Magnus had arranged Aristotelian teachings so that they were again in favor, and he incorporated in his text, from the Arabs, all that was useful to his argument. Heterodox comments were refuted when they were not rejected outright. St. Thomas Aquinas gave an even more solid form to orthodox philosophy and waged persistent war on the specific doctrines of the Arabs. In the year 1277 a series of thirteen propositions, mostly taken from Avicenna and Averroës, was formally condemned at Paris and at Oxford. In the general chapter of the Franciscans held at Assisi in 1295, an especial warning was given against 'exotic' opinions. These instances from the history of a single century indicate that there was no universal stagnation. Condemnations of heterodox philosophizing were required

every twenty years or so. The thirteenth century is so far removed from us, that we only see its larger features and the main trend of its current. Could we take a nearer view all would be complexity. The conclusion is as true of moslem as of Christian Europe.

Hakim II., caliph of Cordova in the tenth century, had a library of six hundred thousand manuscripts. The catalogue alone filled forty-four volumes. He kept agents in residence at Alexandria, Cairo, Bagdad and Damascus to procure for him, at any price, books ancient or modern. Works composed in Persia or in Syria were thus often read in Spain before they were known in the city of the author—witness the *Anthology* of Abul-faradj of Isfahan, for which Hakim paid a thousand gold dinars. His eagerness to acquire was something more than the instinct of the collector, for there are authentic anecdotes of his extensive acquaintance with the biography and history of his times. Even before the reign of Hakim the Moors of Andalusia were inclined to liberal studies. From the tenth to the thirteenth century was the golden age of learning in Spain. Moors, Jews and Christians cooperated in scholarly works under the patronage of princes. The mosques of Cordova were crowded with students. The Giralda tower of Seville (1196) was built for Geber's observatory. The picture is alluring; but we must not fail to recognize that it presents only a part of the truth. In Spain, as elsewhere in Europe, these were the dark ages.

The wealth of manuscripts in the whole of the moslem world was immense. There were, it is said, above seventy public libraries in Moorish Spain alone. The library of the Fatimite caliphs in Cairo contained 100,000 manuscripts, of which 6,500 were devoted to medicine and astronomy. When the Crusaders took Tripoli in Syria (1109) 100,000 manuscripts were destroyed. Private libraries were often extensive. Faizi, the poet-laureate of Akbar, the Great Mogul, had a private collection of 4,600 manuscripts.

Europeans of the twelfth and thirteenth centuries had a veritable passion for collecting manuscripts also. Charles the Wise in 1373 had a library of 900 manuscripts in the Louvre. Boccaccio, in the middle of the next century, complains that libraries were then falling into decay. The Vatican library was founded in 1453 and the Medicean collection at Florence a little earlier. The library of the Duke of Urbino (1474) cost 30,000 ducats and contained all known classic books. We ask with wonder where these manuscripts came from. We must remember that the library at Alexandria possessed every treasure. Its manuscripts were removed to Rome, and thence to Constantinople, and in the meanwhile copied, recopied and copied again. They passed from hand to hand as precious possessions, valued almost as sacred things. The *Sortes Virgilianæ* attributed magical powers to the mere manuscript. Pieces of Homer were sold for charms. Euro-

pean manuscripts were, at first, preserved in churches, and later, in convents and abbeys, where they were copied and recopied and sold at high prices. It is, finally, to the church that we owe their preservation. Wars and strifes were not so fatal to manuscripts in the west as in the east. When Constantinople was taken by the Crusaders (1204), thousands of manuscripts perished. Many others were lost in its three great conflagrations, but in spite of these misfortunes thousands of volumes were preserved and have come down to us. The fragment that has been saved may give some notion of the magnitude of the original collections. Ximenes in the beginning of the sixteenth century burned 80,000 manuscripts in the public squares of Grenada. The magnificent collection of the Escurial comes from Morocco, and at least half of it was destroyed by the fire of 1671.

The Abbaside caliphs were liberal patrons of learning, as was the fashion of their time and race. Harun's quick intelligence was interested in scientific matters and he had very wise advisers. Al-Mamun was even more interested. To patronize science and the arts was a part of the state of a sultan. It had to do with Aristotle's virtue of *magnificence,* now erased from our list of cardinal excellences. The *Almagest* was first translated by learned Jews in the reign of Harun al-Raschid (765–809), and an observatory had been maintained by his predecessors at Damascus. His son, Al-Mamun (786–833) erected a magnificent establishment at Bagdad in 829, sixty-seven years after the foundation of the city. The Arab instruments were fashioned from descriptions given by Ptolemy, but they were much larger and far more accurate than those of the Greeks. Moreover, the Arab astronomers observed the heavenly bodies *continuously,* and this habit led them to a more precise knowledge of the elements of planetary motion. The attitude of an oriental monarch towards learning is well illustrated by a paragraph from the Memoirs of Tamerlane. Tamerlane was nearly a savage, but he had learned from contact with polite nations the fashion of kings, and it is interesting and significant that he cared to be in the fashion. He says:

> Men learned in medicine and skilled in the art of healing, and astrologers and mathematicians, who are essential to the dignity of empire, I drew around me; and by the aid of physicians and surgeons I gave health to the sick; with the assistance of astrologers I ascertained the benign or malevolent aspect of the stars, their motions, and the revolution of the heavens; and with the aid of geometricians and architects I laid out gardens and planned and constructed magnificent buildings. At the Court of Akbar (1575) there were thirty-eight doctors of the law and theologians, sixty-nine *literati*, fifteen physicians, one hundred and fifty-three poets, besides historians, artists, astrologers, three Jesuits, and translators, scribes and clerks without number.

Arab history shows, however, that culture and the desire for culture never penetrated the mass of the people. They were rigid Moslems;

and men of learning were suspected of heresy or worse. An aristocracy of learning has always been more odious to the people than one founded on wealth or birth; and there is no intolerance like that of the ignorant. Their princes could do no act more popular than to order the destruction of heretical books and manuscripts in the public square. All Hakim's manuscripts were so destroyed after his death to conciliate the people. Works on theology, grammar and medicine were alone spared, with a few treatises on elementary astronomy—for it was necessary to be able to calculate the direction in which Mecca lay, the *Kibla* towards which every Moslem turns his face in prayer.

In Arabia, in Spain and in Europe, the mass of the people was fanatical, brutal and ignorant. Dominion over them was gained and held by exciting their passions. The influence of sages, like Bacon and Averroës, of liberal princes, like Hakim and Frederick II., saved learning from extinction; but it has required the experience of centuries to raise the tolerance of new ideas to its present level; and even now, is not tolerance composed quite as much of indifference as of enlightenment? If the history of the renaissance of art in Italy is closely examined a corresponding ignorance and indifference is exhibited. Where art ministered to religion, to superstition or to local pride, the multitude was concerned for it. For art as art, only a select few were interested.

The writings of the Greeks first became known to the Arabs through translations from the Syrian. In the year 431 the Nestorian heresy was condemned at the council of Ephesus. Nestorian priests were banished and dispersed throughout Syria, Persia and the further east, and everywhere carried somewhat of the learning of the west. Under the caliphs they spread from Cyprus to China and outnumbered the Greek and Latin churches. There was a Nestorian bishop in Merv in A. D. 334; and at Herat and Samarkand in A. D. 500. The Kerait Turkomans accepted christianity about A. D. 1000, as a tribe. A Nestorian christian was superintendent of the city schools of Bagdad under one of the Abbaside caliphs. Until the death of Tamerlane (1405) Nestorians were to be found everywhere throughout the orient.

It is doubtful whether a single Arab scholar was acquainted with the Greek language, and certain that none of the Moorish doctors were so. The printed volumes of Averroës' Aristotle are a Latin translation of a Hebrew translation of a commentary made on an Arabic translation of a Syriac translation from a Greek text. The meaning of the original was almost lost in its transmigrations through tongues so different in spirit as Greek, Syrian, Arabic, Hebrew and Latin.

Latin editions of the whole or of parts of Averroës' Aristotle were greatly multiplied in Europe after the invention of printing. During the century 1480–1580 nearly a hundred editions were issued. At Venice alone more than fifty were put forth. It is in Avicenna that

we must seek the full expression of Arab philosophical thought, while Algazel is its most original expositor. The greatest of the astronomers were Albategnius, Ibn Yonis and Abul-Wefa.

Greek made its way slowly in Europe, also, though it was never quite lost. In the tenth century, Sister Hrosvita, a nun of Hanover, composed Latin poems and dramas, learned Greek and read Aristotle. In the twelfth Abelard recommended the nuns of the Paraclete to study both Latin and Greek; and Héloise was acquainted with Latin, Greek, and Hebrew as well. In the thirteenth, Greek manuscripts were systematically collected by a few scholars—Robert of Lincoln, for example; and Roger Bacon's far-reaching proposal for the establishment of schools of comparative grammar for the study of Chaldean, Hebrew, Arabic and Greek, as well as Latin, represents the highest wave of a very widespread current. Petrarch's letters are a proof of a great rationalistic movement in the fourteenth century to which the study of the classic authors of Greece, in their original tongue, was a prime necessity. Neither Petrarch nor Dante knew Greek sufficiently well to read Homer in the original. The council which sat at Basel from 1431 to 1449 to consider the reconciliation of the Greek and Latin churches attracted many Greek scholars to western Europe, and by the fall of Constantinople in 1453 learned Greeks, who brought with them treasured manuscripts, were dispersed throughout all christian countries.

Raymond of Toledo, grand chancellor of Castile, established a college of translators shortly before the middle of the twelfth century, and the works of Avicenna and other Arab philosophers were translated into Latin. In all works of this kind learned Jews bore an important part. The translations were barbarous in the extreme. Each Arabic word was translated into Latin by one clerk, and the construction arranged by another. 'The Latin word covered the word in Arabic as a piece in chess covers the square.' The grammatical construction was Arabic rather than Roman. The style was barbaric. "*Inuarkin terra alkanarihy, stediei et baraki et castrum munitum destendedyn descenderunt adenkirati ubi descendit super eos aqua Euphratis veniens de Euetin*" is a phrase from Hermann, the German, and it bears out Roger Bacon's dictum that students would lose their time, trouble and money over translations of the sort. "Should Cicero or Livy return," says Petrarch, "and stumblingly read his own writings once more, he would promptly declare them the work of another, perhaps of a barbarian."

We have seen that the eagerness of collectors of manuscripts sometimes made Moorish scholars familiar with literary works even before they were published in their native country. Copies were rapidly made and distributed: a popular work would soon be known over the

whole of Europe. "The French poems of the *trouvères* were, in less than a century, familiar in translations into German, Swedish, Norwegian, Icelandic, Flemish, Dutch, Bohemian, Italian and Spanish. A work composed at Morocco or Cairo was known at Paris or Cologne in less time than is now-a-days required for an important book published in Germany to cross the Rhine" (Renan). To this intellectual movement the commerce of the Jews powerfully contributed. If there were any demand for a particular manuscript they promptly supplied it. Books of science were, naturally, not multiplied with the same rapidity as works on medicine and philosophy, but whatever demands existed were supplied. A knowledge of Latin was widely spread among the Jews. In the thirteenth century Solomon of Barcelona reproves his co-religionaries of Provence for neglecting the study of Hebrew in their eagerness to acquire the Roman tongue.

Civic toleration has seldom been carried further than among the Arabs in Spain. Cordova was preeminently the city of learning; Seville of gaiety and music. Jews, Mohammedans and Christians were on the same official footing and spoke the same language. Hebrew and Spanish were often written in Arabic characters. John of Seville, a christian bishop, translated the Bible into Arabic. In spite of the opposition of the clergy mixed marriages were not very infrequent. This fact indicates that toleration had already begun to penetrate the mass of the people; yet this must not be taken as a general conclusion, for at the slightest sign religious feuds broke forth. It is probably more true to conclude that tolerance was the mark of liberal princes. Jews and Christians had a place among the Moors so long as their interests did not clash. There was no real learning among the masses in Spain or in Europe in the days of ignorance. The courts of princes, on the other hand, were alive with intellectual curiosity.

Nothing was easier, however, than for a learned man to get a hearing in Moslem countries before other men of his class. The case was much the same at European universities. Any mosque would serve the Moslem doctor for an audience-hall, and as nearly all mosques had endowed schools attached to them, hearers were provided from the outset. If the teacher was eloquent, pupils flocked to hear him by hundreds. The subjects taught were jurisprudence, logic, philosophy, medicine, mathematics, astronomy. All except the first were derived directly from the Greeks, or from Arab commentators. Of Greek literature, poetry, drama, the Arabs were absolutely ignorant. They did not even know the distinction between Greek tragedy and comedy.

We may perhaps judge of the authority of Aristotle among them by quoting from Averroës's edition of his works:

"The author of this book," says the Arab commentator, is "Aristotle, wisest of the Greeks, who both founded and completed the sciences of Logic,

Physics and Metaphysics" * * * "No one for fifteen hundred years has been able to add anything to his writings, or to find in them an error of any moment" * * * "He should rather be called divine than human" * * * "The doctrine of Aristotle is the sovereign truth, for his intelligence is the limit of human understanding."

A portion of this praise may be laid to the Arab habit of high sounding eulogy which made their ruling princes, 'the Shadow of God'; but the wisest of the pagans, and the christian doctors of all times, have praised him in almost equivalent terms.

Aristotle, in my opinion, stands almost alone in philosophy.—Cicero (106–43 B. C.).

Aristotle, Nature's private secretary, dipping his pen in intellect.—Eusebius (264–349 A. D.).

Whenever the divine wisdom of Aristotle has opened its mouth, the wisdom of others, so it seems to me, is to be disregarded.—Dante (1265–1321).

Aristotle was a man beside whom no age has an equal to place.—Hegel (1770–1831).

By a singular chance "the greatest of inductive philosophers became the hero of a recklessly deductive age" (Robinson). By a still more singular chance he became the corner-stone of Roman Catholic theology.

The Stagirite agrees with Catholic theism, though not with the Pentateuch, in saying that God is without parts or passions, but there his agreement ceases. Excluding such a thing as Divine interference with all Nature, his theology, of course, excludes the possibility of revelation, inspiration, miracles and grace. (Benn: Greek Philosophers, *i*, p. 312.)

Towards the end of the twelfth century a war on philosophy was set on foot throughout the Moslem world. A theological reaction like that which followed the Council of Trent (1545–63) in the Latin Church sought to conquer lost territory by dint of argumentation and violence. * * * Escaping more and more from the control of the Arab race, essentially skeptic in inclination, Islamism came by accidents of history to be the especial charge of races prone to fanaticism—the Berbers, Spanish, Persians and Turks—and took on the form of an austere and exclusive dogmatism. Islamism in general suffered the fate which befell Catholism in Spain; which would have befallen that of all Europe if the religious revival of the end of the sixteenth and beginning of the seventeenth century had succeeded in stifling all national development.*

The doctrines expounded by Arab writers were exoteric—intended for the mass of men. They taught their esoteric doctrines by word of mouth, or, occasionally, in works not confided to the multitude. Algazel, in his 'Logic,' declares that opinions which he does not share are there exposed, and that in his book on the contradictions of the philosophers his true views are to be found. The problems that he dismisses as insolvable in his published works are resolved in this book of esoteric doctrine. Abd-el-Melik Ibn-Wahib of Seville would not even converse on delicate subjects, 'so that, in *his* writings, one does

* Renan: Averroës et l'averroisme, Chapter I. Like all general statements this one requires completion in order to be exact in all its details; the Persians, for instance, were never austere or dogmatic, so far as I know.

not find, as in those of other philosophers, secret matters only to be expounded after they are dead.' Avicenna explains the views of others and conceals his own, and avows that beside his published works he has written a treatise in which he has expounded philosophy 'according to Nature and Reason alone.' This was his *Oriental Philosophy,* now lost, if indeed it was ever current. On this declaration of Avicenna, Roger Bacon comments: "The naked truth cannot be told. Avicenna well knew that the envy and pride of his rivals, and the folly of the multitude forced him to speak like all the world in his published works, and he knew that he could only think the pure doctrine of Science for the few." The 'pure' doctrine of Avicenna was a pure pantheism—God was identified with the revolving spheres. Bacon expressly rejected this identification without ever knowing what Avicenna's last word was.

Students flocked to schools wherever the desired instruction was provided, as indeed, they always had done. In the sixth century 'Lismore's learned isle,' off the bleak Scottish coast of Oban, was visited by scholars from every part of Europe. In the twelfth, the Moorish universities held some students from countries as distant as England as well as many from Italy and France. To seek for the situations of the foci of learning in different centuries would be a curious inquiry. The excursion would extend from Turkistan to Tunis and Toledo.

Consider also the narrations of the voyages of travelers that began to be current. Benjamin of Tudela (1173) visited regions so distant as Samarkand and India. Jean Carpin, the Franciscan, was sent (1246) by Pope Innocent IV. on a mission to the Tartars, and Rubruquis (1253) to the same people by St. Louis. Marco Polo returned from China and India in 1295. Sir John Mandeville's travels in the orient (in the middle of the fourteenth century) were recorded by him in three languages and were copied everywhere in Europe. Consider, also, that well traveled trade routes existed throughout the nearer east and that the products of all the orient were familiar to the cities of Italy and southern France. The minds of men were opened by the recitals of the experiences of returning travelers. Abbey schools and great universities were everywhere to be found. The learning of the time was within the reach of multitudes.

What the mathematical courses in the English universities were, even in the sixteenth century, is illustrated by a curious passage from the Oxford lectures of Sir Henry Savile (1549–1622): "By the grace of God, gentlemen hearers, I have performed my promise; I have redeemed my pledge. I have explained, according to my ability the definitions, postulates, axioms and the first eight propositions of the Elements of Euclid"—eight propositions! Dante in the *Convito* gives the classic scheme of studies in European universities slightly modified

to agree with the nine heavens moved by angels or intelligences, the supreme sphere resting in God himself.

LIBERAL ARTS	*Trivium*	Grammar	Moon	Angels
		Dialectic	Mercury	Archangels
		Rhetoric	Venus	Thrones
	Quadrivium	Arithmetic	Sun	Dominions
		Music	Mars	Virtues
		Geometry	Jupiter	Principalities
		Astrology	Saturn	Powers
PHILOSOPHY	*Physics and Metaphysics*	Starry Heaven		Cherubim
	Moral Science	Crystalline Heaven		Seraphim
	Theology	Empyrean		God.

About the end of the fifteenth century a revolt against the Aristotle of the Arab commentators took form in Italy. On April 4, 1497, the first lecture from the original Greek text was given at the University of Padua. The 'vain glosses' of the Arabs were decried by the most distinguished among the teachers of the sixteenth century. Hippocrates and Galen were infallible only in Greek. In 1552 the preface to an edition of Averroës declared: "Our ancestors could find nothing ingenious in philosophy or medicine unless it came from the Moors. Our own age, on the other hand, trampling Arab science under foot, admires and accepts only what comes directly from the treasury of Greece; it adores the Greeks only; it will have only Greeks for masters; he who knows not Greek, knows nothing." The Arab Aristotle became 'a poisoner; an obscurantist; the executioner of the human race, who has destroyed the world with his pen as did Alexander with his sword.' The new school conquered in the end, but not without a long struggle.

In Petrarch's time the doctrines of Aristotle had taken on an aridity from the Arab commentators that cried for a living spirit to replace it.

"Petrarch deserves the name of 'the first modern man' in that he first introduced to the Latins the fine feeling of antique culture, the source of all our civilization. * * * It was he who first rediscovered the secret of that noble, generous and liberal comprehension of life which disappeared when the barbarians triumphed over the ancient world."

When Arab philosophy was finally overthrown in the early part of the seventeenth century (we may fix the date at the death of Cremonini in 1631) the liberty of opinion that then prevailed in the northeast of Italy vanished completely. The day of conflict was over. The reign of orthodoxy began anew. The final defeat of the Arabs was, on the one hand, a sign of the victory of experimental science; and on the other, it cleared the way for a rigid orthodoxy.

During the period when the struggle between the Arab and the Greek Aristotle was in full progress it was inevitable that liberty of

opinion should prevail. At its end two consequences necessarily followed, as has just been said: The essential validity of the methods of experimental science had been vindicated, and scholars understood that a new era had begun. This was the era illuminated by Galileo's early researches. On the other hand, the Greek Aristotle had conquered. The liberty which comes of conflict was no longer permitted. Orthodoxy founded itself on the new interpretations and reigned firmly and severely. To the people at large the end of the conflict marked the overthrow of speculative heresy, not the winning of a new world to science. The pantheistic idealism of Averroës and the Arabs lingered on in a few minds. Cardan, Pomponazzi and Jordano Bruno were tinged by it. But in the church orthodoxy ruled.

During the early centuries of the christian era no one was concerned to vindicate the claim of the church of Rome to primacy. The bishop of Rome was the successor of St. Peter; his church was the mother of all the churches; it was situated at the capital of the empire. These were its sufficient titles. About the year 500 'apostolic canons' were collected which afterwards grew into the canon-law. Precepts from the Bible, extracts from the writings of the fathers, decrees of church councils, letters (decretals) of the Roman bishops, formed the body of a distinctive law of the church. But in the schools of Italy the memory of the civil law of the empire had never wholly died out. Early in the twelfth century Irnerius was lecturing in Bologna on the *Corpus Juris* of Justinian, and from such studies the university arose, just as the University of Paris grew from the teaching of Abelard. A pupil of Irnerius lectured at Oxford. The universities of Paris and Oxford were, however, chiefly concerned with theology and with general culture—with the *quadrivium* or group of higher scientific studies.

The teachings of Bologna (in law) and of Salerno (in medicine) were more special. They necessarily implied an acquaintance with classic writers and with the history of the empire. It was inevitable that the question of the legal status of the church should be discussed. When and how was it recognized by the empire? What were its legal sanctions? Upon what grounds were the canon and the civil law to be reconciled? These were soul-stirring questions which the church subsequently answered in its own way. With the answers we have no concern. The civil law dealt with every one of the personal and social relations of mankind; it had to do with the whole life of civil society; its principles were not immediately related to the principles underlying the body of the canon law.

The origins of what we call the revival of learning must be sought in the discussions that inevitably arose from the comparison of principles so different, and the consequent necessity of an appeal to the original writings of authors of classic times. The renaissance had its

formal beginnings in the Italian schools of the early years of the twelfth century.

The history of the first half of the thirteenth century is a proof that the leaven of a revival was then working at Oxford, at Paris, in Robert of Lincoln, in Roger Bacon, at other places, and in many other companies of men. Long years before the savants of the renaissance, Bacon urged the study of the dead languages, of philosophy, of mathematics, of classic literature. Centuries before Luther he pointed out the errors of the Vulgate, and of the fathers of the church. The way was prepared for Petrarch, though in fact he only appeared a full century later. What is the reason of this sudden check to a vigorous and healthy movement? No single cause was more efficient than the rehabilitation of Aristotle as the apostle of orthodoxy towards the year 1250. The advent of 'the first modern man' was delayed for a hundred years, and the later renaissance for three centuries. The wars of the fourteenth century drowned European learning in blood. The history of the promising beginnings of a real revival of learning in the twelfth and thirteenth centuries is not yet written, and the share that the scientific thought of Bacon and his contemporaries had in such a revival has been strangely undervalued. Science, as one of the motive forces of the whole movement, has been neglected. It is the rarest thing to find in the indexes of professed histories of the renaissance the name of any scientific man—even that of Copernicus almost never appears.

The earliest stir of the renaissance was in Italy. Petrarch was the first great man of the new world, as Dante was the last of the old. Germany, the seat of the Holy Roman Empire, felt the impulse quickly on account of its close connection with Italy, and each one of its semi-independent courts was a focus favorable to the new spirit.

The discoveries of Columbus in 1492 were a mighty aid in freeing men's thoughts from the shackles of prescription and custom. The voyages of Vasco da Gama to India (1497–99) and of Magellan around the world (1519–21) came to confirm the larger view and to excite curiosity and hope. New things are within our reach; search and find—these were the lessons of the time. They were lessons for all mankind. Even the peasant heard of the new wonders and felt himself more a man. The philosopher, in his study, was incited to new efforts. A new spirit was born throughout civilized Europe.

To estimate an epoch, something must be known of its arts and inventions. During the middle ages gunpowder, clocks, telescopes, parchment, paper, the mariner's compass were invented or adopted; mathematics received great developments—especially algebra and trigonometry; perspective was studied and perfected; experimental chemistry, not yet a science, was cultivated; surgery was brought to an equal standing with medicine; music, as we know it, began with the notation

of Guido d'Arezzo; counterpoint was developed into a doctrine; optics and acoustics were greatly improved and the foundations of mechanics were laid; manufactures of all kinds made great progress, notably those of glass and steel; the art of printing opened literature to all the world —the poor and the rich alike.

If we pass to the field of art there are notable matters to be chronicled. All the basilicas of Italy, all the mosques of the Arabs, all the Byzantine churches, all the Gothic cathedrals are of this period. Santa Sophia dates from A. D. 532, St. Mark's from 1052, Notre Dame from 1163, the Cathedral of York from 1171, St. Peter's from 1450. Of the great painters, Cimabue was born in 1240, Giotto in 1276, Van Eyck in 1366, Botticelli in 1447, Leonardo in 1452, Dürer in 1470, Michel Angelo in 1474, Titian in 1477, Raphael in 1483, Correggio in 1494, Holbein in 1495, Tintoretto in 1512, Veronese in 1532. The dates, set down almost at random, cover a thousand years, but the epoch of great progress was from the twelfth to the sixteenth century. When we thus sum up what was accomplished in five hundred years, the period is seen to be full to overflowing. Its interests did not lie in the direction of science—its ideal was not comfort. At the beginning of the dark ages the problem of Europe was to tame the hordes of barbarians who had possessed themselves of the lands—to contrive workable compromises between the customs, laws, ideals, institutions of northern and southern races. Given the point of starting the progress is not slow. The advancement of Europe from the sixth to the sixteenth century is an amazing phenomenon and no one can study it closely without a sense of wonder that so much was achieved.

We who breathe a different air must never forget that the doctors of the church cared little for science, as such, and everything for religion. In the *Summa* of St. Thomas Aquinas there is but one chapter that deals with scientific matters. Moreover, we must always carefully distinguish between the opinion of the philosophers and that of the multitude. The mass of men then, as now, thought little of philosophical matters and took their opinions ready-made. Real tolerance in philosophy is a product of real experience. Princes like Al Mamun and Alfonso X. patronized learning in a large and liberal way. The crowd of doctors, poets, artists, physicians, astronomers, at such courts lived in a harmony which was enforced upon them by their very situation. Outside the courts there was envy and malice among the excluded theologians, a sullen opposition among the people. What men do not understand they suspect as heretical. There is scarcely a moslem or a christian doctor of the middle ages who did not bear the reputation of magician among the common people. Medicine, astrology, alchemy were, almost necessarily, regarded as magical arts. To a populace that sincerely believed in ubiquitous devils all science was suspect.

Considerations of this sort should make us very tolerant of the blunders of our brothers of past time. It is so easy for any one of us to make a list of the follies, errors and crimes of his own century, and so hard to find excuses for them, that it should give us pause in distributing indiscriminating blame to the men of the middle ages as is often done in books of the warfare-of-science-and-theology sort. Among us, as of old, the ignorant are the most harsh. To us, as to the middle ages, the phrase *Tout comprendre c'est tout pardonner* applies in its fullest force and scope.

During the whole of the middle ages there was never a time when a philosopher was not free to put forth his scientific conclusions hypothetically—as theories to account for observed phenomena. He could not, however, directly attack religion, or even roughly handle received opinion on religious matters. At many epochs the first breath of heresy was fatal. Our own age is not very tolerant of attacks upon cherished beliefs. It is in a great degree its indifference to a certain class of inquiries that gives us our present liberty. Had Copernicus lived, his doctrine would not have given rise to scandal in the church, because it was put forth as a distinctly scientific opinion quite detached from theological suggestions. It was not until 1616 that his book was placed upon the index, and then only as a consequence of the personal enmities that Galileo's bitter satires had excited. If Roger Bacon had been willing to follow the methods of Copernicus the long miseries of his life would have been spared and the world might have been saved from three centuries of wandering in devious and ill-directed paths. If Galileo had done the same he would have lived in peace; we should have owed our present freedom to another martyr.

It is the custom of our minds to escape difficulties by accepting symbols to stand for ideas, types to stand for men, and we stand in danger of losing realities in the types and symbols. The sculpture of the Greeks is summarized to us by a couple of names; but there were many great sculptors in Greece beside Phidias and Praxiteles. The astronomy of the sixteenth and seventeenth centuries can show a large list of noted names; but it is epitomized in Copernicus, Tycho, Kepler and Galileo. It is commonly taken for granted that Copernicus burst forth from darkness and made a new epoch. He stands, indeed, for a new epoch; but he was no less the product of his time than Darwin, another *Bahnbrecher*. There was great activity among astronomers in the decade just preceding the publication of his great book in 1543. Copernicus was the child of universities; the schools of Italy which he frequented for years were alive with inquiry. The epoch for a revision of accepted theory had arrived. It was the encouragement of his friends and scholars that brought about the promulgation of his theories, all of which were fully comprehended by them, before even a

line had been printed. Had Copernicus never been born there is no doubt that the heliocentric theory would have been announced before the sixteenth century reached its end. Tycho's observations contained it implicitly. It could not possibly have escaped the eager search of Kepler.

Tycho, again, stands as the type of the men who saw that a multitude of accurate places of the heavenly bodies must be accumulated before any adequate theory of their motions could be formulated. The Moors of Spain, the Arabs of Bagdad, the Turkis of Samarkand grasped the same fundamental idea, and other astronomers in Italy and in Germany were in the same path before Tycho.

Who shall say how much Kepler owed to his master, Moestlin, to whom he is never weary of attributing the suggestions which finally culminated in his splendid discoveries?

Galileo's great achievements in astronomy were largely due to the telescope, which he was the first to use, although it was invented by others. His greatest gift to science is his theory of mechanics, but even here Leonardo da Vinci had already gone far on the true way, and his contemporary, Stevinus, developed the whole subject independently and with equal insight. Galileo was surrounded by men of his own class if not of his own stature.

We, in our turn, may accept these four great men—Copernicus, Tycho, Kepler, Galileo—as types; but we must never forget that they did not stand alone. Each one of them shone with brilliant and intrinsic light, but each one was, also, in some degree, the mirror of his age, concentrating and diffusing the reflections of lesser lights by whom he was surrounded. What he received from them as mist, he returned in rain, as has been finely said of the inspiration of an orator by his audience.

Of this group of four, two are veritable epoch-makers—the first and the last. After the book of Copernicus was understood, the world was no longer the same. Its center had been changed. The sun and not the earth ruled our system. The planets and the stars became the sun's ministers, not ours. Man, *nodus et vinculum mundi*, was discrowned and disenthroned. It was the doctrine of Copernicus that changed the face of the world.

To realize the momentous change time was necessary. It was Galileo who spoke the emphatic word. The predictions of Copernicus were confirmed by the telescope. The new doctrines were explained and enforced so that no escape was possible. It was Galileo and not Copernicus who convinced the reluctant spirits of his day. The work of one was continued in the other. Not until the time of Newton was the message fully credited. It was not welcomed until our own day.

To the men of the middle ages the world was a little space shut

tight within a wheelwork of revolving spheres. It was compendious, complete, ingenious, like a toy in a crystal box. Beyond the outer shell nothing existed. The heavens were incorruptible. No change could occur in the whole system, save on the earth alone. The universe was created for the sole use of man. It was small and finite. To us, the awful infinitudes of space are only to be faintly imagined after a series of conceptions, each one so overwhelming that it fades after the briefest instant of realization. Human attention can not grasp the whole series in one view. Each one of the myriad stars is a sun like our own, subjected, as it is, to prodigious physical alterations and catastrophies. Each one is, perhaps, surrounded by a train of planets, like those we know, that must forever remain invisible to our vision. The condition of every celestial body is perpetually changing in a long progress of evolution. Each separate star is situated as far from every other as our own sun from the very nearest of them all. Every star is in motion. The sun, so mighty and all-powerful to us, is but a feeble light among thousands of millions of others scattered so sparsely throughout the never-ending expanse that centuries are needed even for their light to traverse the intervening spaces. In the feeble light of that sunbeam, vital to us, the earth, our mother, shines like the merest mote. Its past is limited, its future insecure. With its finite history the fate of mankind is bound up.

We must not forget that the modern view of the universe is very different from that of Copernicus. Before his day the earth was motionless in the center of the world. After it the earth was in perpetual motion about the sun. Copernicus conceived the sun as fixed. But under Newton's law of universal gravitation there can be no fixed bodies. All are in motion. Our sun with its train of planets is speeding through space towards a goal as yet unknown. Newton's law of gravitation banished rest from the universe. To Copernicus as to Ptolemy rest was the natural state to which all bodies tended. They moved only when perpetually urged. The science of mechanics founded by Galileo and Newton changed all this. The real reformation of science dates from the acceptance of the new conception.

LIFE IN OTHER WORLDS.

By F. J. ALLEN, M.A., M.D., Cantab.,
LATE PROFESSOR OF PHYSIOLOGY IN MASON UNIVERSITY COLLEGE, BIRMINGHAM.

THE question 'whether life exists in any other worlds than our own' is one in which very many persons feel an interest, and about which much has been said and written; but if the man of ordinary education has any ideas on the subject, they are generally mistaken; and even scientists are prone to regard it too exclusively in the light of their particular science, and thus to conceive and propagate fallacies which might be easily avoided.

Of course no absolute answer to the question can be given until perchance some hitherto undreamt-of means shall be discovered for the observation of distant worlds. We can hardly forward the matter by mere speculation on general grounds, such as the law of probabilities, or the relative position of worlds in the universe. Nevertheless there is one method by which we can at least guard ourselves against erroneous speculation, and prepare the way for discovery when the opportunity comes; and that method is, to find out the conditions on which terrestrial life depends, and then to search other worlds and find if possible whether they provide similar or parallel conditions.

Though the ultimate nature of life is as yet unknown to us, its secrets are being gradually unraveled by research; and it becomes more and more apparent that the phenomena of life are but special and intricate developments of physical action. The most prominent and perhaps most fundamental characteristic of life is what may be called the *energy traffic,* or the function of trading in energy; and the phenomena of assimilation, growth, movement, etc., are the outward and visible signs of this traffic. Living substance possesses in the highest degree the property of absorbing radiant energy, as heat or light, storing it in a potential form, and subsequently expending it in active forms such as motion, mechanical work, heat and electricity.

Actions of this kind are not unknown in the inorganic world. For example, the atmosphere and ocean absorb the energy of light and heat from the sun, store it temporarily and convert it subsequently into the energy of wind and wave, lightning and thunder. But in living substance there exists a more finely coordinated energy-trading system, evolved out of the chemical capacities of a small number of elements acting under the physical conditions which prevail on our planet.

The energy traffic depends, no doubt, on causes at present unknown to us; and some biologists are wont to personify these causes as a

'vital force,' an influence (sometimes regarded as external) which modifies the behavior of matter and energy without affecting their quantity. But as we can not exclude the probability of similar directing and modifying influences in the inorganic world, it is best provisionally to regard the causes of life as present alike in living and not-living substances—conspicuous in living substance because coordinated, but hardly observed in not-living substance, owing to incoordination. If a simile be needed, it may be found in the behavior of light: for certain properties of light, though ever present, become evident only when coordinated by polarization; and polarization, be it noted, is a purely physical action.

While every element present in living substance may assist in the work, the energy-traffic is carried on chiefly amongst the four elements, nitrogen, oxygen, carbon and hydrogen. Nitrogen is remarkable for the instability of its chemical compounds—the readiness with which they change their composition—and there is little doubt that on this property depends the extreme sensitiveness of living substance. Carbon and hydrogen have the property of combining together to build up complex compounds, with great storage of potential energy; whereas the same compounds during their oxidation expend their energy in the form of mechanical work, heat, etc. The energy traffic consists of two alternating phases: (1) the *accumulation* of energy, or 'anabolic' phase, which is always coincident with deoxidation and the formation of complex chemical compounds: and (2) the *dispersion* of energy, or 'catabolic' phase, coincident with oxidation of the complex substances, which are thereby converted into simpler substances, as carbonic acid and water. In these processes nitrogen is intimately concerned: it is believed to act as the carrier, taking up each element or group of elements and passing it on in a new state of combination.

All the energy of life is derived ultimately from the sun. A little of this comes indirectly through lightning, which in passing through the air forms ammonia and oxides of nitrogen. These, being carried by rain into the ground, are the constant source of nitrogen for vegetable, and indirectly for animal life. A much larger quantity of energy is well known to be taken direct from the sunshine by plants and used in their anabolic processes. This energy is appropriated by animals in their food; and whether in the vegetable or in the animal, it assists in many alternations of anabolism and catabolism before it is completely dispersed.

The range of temperature suited to terrestrial life is comparatively narrow. All vital actions are suspended temporarily, some permanently, if subjected to a temperature near the freezing point; while the highest that most organisms can bear lies somewhere between 35° and 45° Centigrade (95° and 113° Fahrenheit). Only the spores of certain bacteria can survive boiling. It is therefore probable that if

the general temperature of the earth's surface rose or fell 40° (a small amount relatively), the whole course of life would be changed, even perchance to extinction. The record of the fossiliferous rocks shows us that for countless millions of years a large portion of the earth's surface has had a temperature much the same as it now has; it is even probable that the surface temperature never greatly exceeded 40° C., though the interior was, and is, very hot.

Water plays an indispensable part in both the environment and the internal chemistry of life. It forms more than half the weight of most living things; and all the actively living parts of animals and plants (*e. g.*, the nuclei and protoplasm of cells) consist of water holding the other ingredients in solution or suspension.

Every one of the conditions above mentioned (supply of energy, particular elements, range of temperature, abundance of water) is essential to life— *i. e.*, such life as is known to us; and it is difficult to avoid the conclusion that this life is really the outcome of the conditions existing on our earth, and that only in worlds with identical conditions can identical life exist.

It is quite odd how, in spite of the advance of biological science and the acceptance of the principles of evolution, the notion still prevails that life in other worlds is similar to that of our earth. We find astronomers searching for the absorption bands of chlorophyll in the spectrum of Mars; marks on planets are described as probable vegetation; some worlds are supposed to be uninhabitable because they have no atmosphere, others because the temperature is too high for the existence of 'protoplasm.' All this indicates a very contracted view of the nature of life. Chlorophyll, respiration, vegetable, animal and protoplasm are earthly phenomena which may exist nowhere else: their place may be taken in other worlds by other phenomena no less wonderful. What we know of terrestrial life gives us reason to think that the same principles which produce life under earthly conditions may produce life of a different type under different conditions; *e. g.*, where the temperature is different, and a different set of elements are available.

It must be freely admitted that we do not know what elements could take the place of nitrogen, carbon, etc., under conditions differing from those on our earth. All speculations concerning this question have been based on misconceptions of the functions of the elements in life. We may only venture so far as to say that certain elements suggest possibilities of energy traffic by reason of the varied character of their compounds: such are phosphorus, sulphur, iodine and iron. Other elements, such as aluminium and silicon, are remarkable for the monotony of their known chemical actions. . . .

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In order that any world may support life comparable with the life

that we know, the following conditions, among others, are necessary, namely, (1) A supply of radiant energy which is intermittent or variable, (2) one or more elements which (like nitrogen) are very sensitive to changes of energy, and (3) one or more elements which (like carbon and hydrogen) are capable of alternately accumulating and dispersing energy by means of opposite chemical changes.

Since popular ideas as to the physical conditions of other worlds are generally hazy and often far from correct, it may not be amiss to recount such particulars as astronomical research has revealed in the members of the solar system.

In looking for a world where the conditions are most like our own, we naturally turn first to Venus. Her size and gravitation are nearly the same as those of the earth, and her atmosphere may therefore be expected to have a similar density and to hold approximately the same gases. As she is nearer the sun, the general temperature would be considerably higher, and the equatorial region might be too hot for our life; but there might nevertheless be a suitable temperature nearer the poles. But our speculations are damped by a suspicion, strong but not fully confirmed, that Venus has no day and night, but always keeps the same side toward the sun. If this is really the case, then the sunny side must be always burning hot and quite dry, while the opposite side must be always encased in ice—nay more, in a mixture of ice and solidified atmospheric gases. The life of such a world must be very different from any that we know.

After Venus, Mars is the planet whose conditions seem most to resemble those of our world. But there are far greater differences than are generally supposed. Mars is so small that he can not provide much heat from within, and so far from the sun that he receives comparatively little heat from without. His gravitation is so slight that the atmosphere is rare and nearly cloudless, and therefore heat must be readily lost by radiation. Thus on theoretical grounds Mars should be intensely cold: in fact his surface should be constantly in the condition of the highest mountain-tops of our world, only receiving less heat than they do from the sun. At such low temperature and pressure, water could never exist in the liquid form, though it might be solid or gaseous. But water is very possibly absent from Mars. Dr. Johnstone Stoney has calculated, by application of the dynamic theory of gases, that any water vapor introduced into the atmosphere of that planet would escape into space, the gravitation being there insufficient to retain it. Professor G. H. Bryan, calculating from slightly different data, questions Dr. Stoney's conclusions; but at all events Mars's gravitation is very near the dividing line between the ability and inability to retain water. If water is absent from Mars, then the polar caps and other seeming evidence of its presence must be due to some other fluid or gas, having heavier molecules and lower freezing and

boiling temperatures. Dr. Stoney himself holds that carbon dioxide would give the appearances of vapor, frost and snow, which are seen with the telescope; and there are still heavier gases which might be imagined to be present. In any case, the conditions seem quite incompatible with life of our earthly type.

As already hinted, the atmosphere of a world depends on its gravitation. Gases tend to diffuse into space, unless retained by adequate attraction. Our earth can hardly retain so light and mobile a gas as hydrogen; Mars may have difficulty in retaining the less mobile vapor of water; but the gravitation of the moon is too slight to retain any known gas, hence she has no atmosphere and no water. Yet this is not sufficient reason for assuming the absence of life. The surface of the moon is usually considered to have been for a long time in an inert state. If it had been so, the accumulation of meteoric stones and dust during ages would have covered it with a uniform veil. Instead of this, the surface presents much variety of tint and texture, indicating a still continuing geological activity; and some changes in its markings are said to have been observed in recent years. Professor Lapworth, regarding it with a geologist's eye, feels convinced that the moon is an active and living world. The geological activity may be the result of the extremes of temperature which are produced by the regular alternation of a half-month's sunshine and a half-month's darkness. At the same time such extremes might awaken to vital activity elements which behave as dead on this earth.

In contrast to the moon are the very large planets, Jupiter and Saturn. Owing to the high gravitation, the atmosphere of such planets is very dense, and so loaded with opaque particles that we can not see through it to the body of the planet within. But though the body is beyond our scrutiny, we can infer that it is very hot, even at the surface; for if the solar system was formed (as is assumed) by condensation of a nebula, the heat of condensation must be proportionately greater and longer retained in a large world than in a small one. Thus for the purposes of life on these great planets the energy radiating from within may be available, and indeed may largely exceed the energy received from the sun at so great a distance. The satellites of these planets may resemble our moon, except that they receive much less energy from the sun.

Of Uranus and Neptune we know very little; but their large size leads us to suppose that their physical conditions may have some resemblance to those of Jupiter and Saturn.

What can we say of the possibility of life in the sun? The visible surface or photosphere has a temperature so high that even iron exists there as a gas, and almost all chemical compounds known to us may be dissociated. The deeper parts are doubtless far hotter still, with chemical possibilities or impossibilities beyond our comprehension. In

fact the chemistry of the sun is of so different an order from any that we have experience of, that we can not reconcile it with any of our notions of life. But if such a vast fund of energy can run to waste without producing life except in distant planets, there must be in nature an extravagance such as almost to justify those persons who imagine our own world to be the only one bearing life, and the whole universe to be made for man.

These few particulars, which we have learned concerning the physical conditions prevailing in other worlds of our solar system, are distinctly against the probability of their possessing life similar to that existing in this world. If they contain life, even life depending on the same principles, it must be quite different in its manifestations, and not easily recognizable with the telescope. If any germ of life should escape from this world and land upon another member of the solar system, it must pretty certainly perish for want of the necessary conditions. The same might be said of a germ from another world landing on our earth—if indeed we have any right to speak of a 'germ' from another world, since the word is geomorphic, and actually assumes that similarity which we hold to be improbable in life under different conditions.

Whether any members of other solar systems resemble our own in physical conditions is naturally a matter of pure speculation; but there is no *a priori* impossibility, since the spectroscope shows that many of the fixed stars contain the same elements as our sun, and have about the same temperature.

* * * * * * * * * *

We are considering only such life as depends on the same principles as earthly life. We may admit the possibility of other kinds of life, having nothing in common with such life as we know, but at present we have no grounds for speculation concerning them. Keeping within the bounds of legitimate induction, we are led to the following conclusions:

1. If life is essentially a function of the elements nitrogen, oxygen, carbon and hydrogen, acting together, then it can probably occur only on exceptional worlds, with conditions closely resembling those of our own earth. Such conditions are not present in any other world in our solar system, nor can they be expected to occur frequently in members of other systems.

2. On the other hand, if different conditions can awaken a capacity for exalted energy traffic among other elements than those just named, then the universe seems to provide immense possibilities of life, whose variety and magnificence may far exceed anything that we can imagine.

THE NEW WEST POINT.

By WILLIAM J. ROE,
NEW YORK.

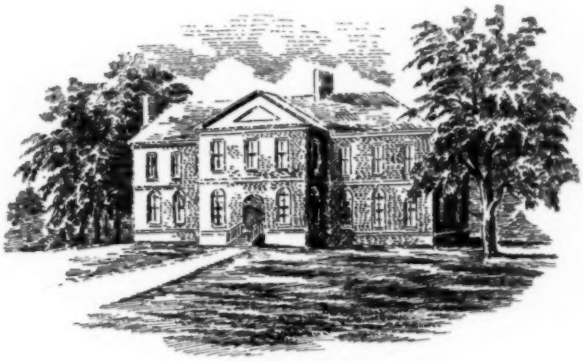
IN the year 1802, by act of Congress, the United States Military Academy was established at West Point on the Hudson River. The experience of Washington during the war of the revolution with the militia of the several states and with raw volunteers was convincing as to the necessity for a permanent military establishment, and especially for the creation of a considerable body of officers sedulously trained in the art of war. The sentiments of the people then, and for many years after, were not favorable to the formation of a standing army, and it was not until the many and serious reverses of the land forces in the 'war of 1812' that any progress was made at West Point in the way of educating officers for their country's service. In the year 1817,—James Monroe being president and George Graham of Virginia secretary of war, Sylvanus Thayer, of Massachusetts, became superintendent of the academy, and at once began a system of instruction and discipline so complete and admirable as to have been maintained in almost the minutest detail to the present day. General Thayer remained at the head of the academy until 1833.

During the period between the close of the war with Great Britain and 1846, the sole opportunity for the graduates of West Point to prove their value was upon the frontier as it then was, the Rocky Mountains and the 'Plains' in contest with hostile Indians. In this sort of warfare there was more room for the display of the forester's and trapper's craft and experience than for the exercise of tactics or 'grand-strategy,' and the consequence was that again the people grew impatient with the appropriations for the academy's maintenance. By this time a numerous body of officers had been graduated, and the idea of a thousand or more men with a life tenure of office and something akin to 'special privilege' and European exclusiveness did not find favor with either 'democrats' or 'republicans.' About this time it was in fact seriously contemplated to abolish the academy altogether. It is more than probable that this would have been done by congress, if at this juncture the Mexican war had not suddenly burst upon the country. We have, it must be confessed, but little to be proud of as to the origin of this war, or to the aggressive and not wholly unscrupulous terms that were finally forced upon Mexico; but the war accomplished at least one good result by demonstrating the merit and necessity of trained leaders. With a

little army of only a few thousands, officered almost wholly by West Point graduates, Winfield Scott marched from the Gulf to the Valley of the City of Mexico, gaining victory after victory, to finally dictate the terms of peace from 'the Halls of Montezuma.'

The change of sentiment among the people as to 'graduated cadets' was instantaneous, and from that day no thought has found expression adverse to the interests of educating and maintaining a considerable body of competent officers.

The reasons for the people's change of sentiment are not to be found alone in the proved ability of West Point men in campaigning, or in any superior valor in action. Others than graduates have shown great skill in strategy, and the volunteer has always been easily his



THE FIRST ACADEMY.

equal in courage and endurance, with perhaps that moral advantage of not being a 'hireling soldier.' It is that through now a full century the record of the graduates of West Point has been spread before the country, and has been found to be on the average so exceedingly high as to be a matter not only of congratulation, but astonishment. There are West Point men who have gone badly astray; some have been promptly cashiered out of the service; others have fled with ill-gotten spoils beyond a 'process,' and others yet have had short shrift in a penitentiary. There are such, but they are marvelously few. Not only in the army, but in civil life, the standard of honor and of integrity has been and is marvelously high.

This has come, not that among the four thousand graduates the same blood does not run and the same influences work for good or ill as among a similar number of others; if they are on the average more high-minded, more duteous in every department of life, it is that the penalty for departure from the straight and narrow path is so extremely swift and terrible. What is true in this respect in the army and in business affairs is true perhaps to a greater extent in the

academy itself, and there indeed it is that the foundations of probity in after life are laid. For four long years—with one brief furlough the third year—the West Point cadet seldom if ever leaves the academy at all; collegians have long vacations; the cadet has none; youths in training for business may spend much time with their families; the student at West Point has no such opportunities. Again it is not with him as with others in trade or at most educational institutions, that he is 'under masters.' There are professors and instructors, a commandant and 'tactical officers,' but as to discipline and all matters of moral obligation, the corps of cadets *governs itself*. From the cadet adjutant and captains to the corporals, and even men-in-the-ranks 'on duty,' each cadet is bound by the strongest of obligations to report violations of regulations. That which would have been called in the large school which I attended in early youth 'telling tales,' is here not only permissible, but an essential part of the academic discipline. Instruction in science, tutelage in the war-course; these go hand in hand; but far more efficient for real and vital education is the constant presence of the spirit of self-training and self-conquest in the molding of true character.

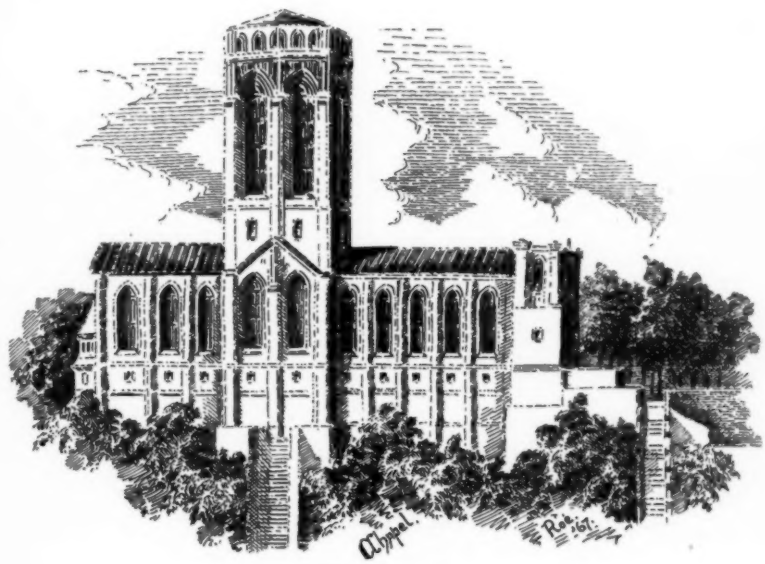
Other institutions outrank the military academy in perhaps all branches of strictly scientific education; some of the refinements of high culture are neglected, and literary excellence is ignored; but as a school of the art of living it is incomparable, as a school of the science of character it is unique.

At the close of the war between the states our regular army was left in a somewhat disorganized condition. In the process of re-organization and increase, there came into the service a very considerable number of commissioned officers who had earned a sort of right to retention in the new army by reason of exceptionally good service as volunteeers. Many of these new appointments had been high in rank—some even generals—who now were content to act as mere file-closers. Some of these were political appointments, and the most inefficient were in due time weeded out; but by far the majority were men of long experience in the field, well worthy of their commissions.

At the time of the breaking out of the Spanish war it was these men, appointments either from the army or from civil life, who by the natural process of seniority had arrived at the highest rank, and it was chiefly upon them that the responsibility rested of commanding troops in the ensuing campaigns. The record of these men is so open and so recent that it appears unnecessary to particularize. They made many mistakes, but on the whole their actions were marked with singular skill, and the results that they achieved were remarkably successful.

Such having been the case, it would not perhaps have been unnatural if the veterans of the civil war had been rather disposed to magnify their own opportunities, even possibly to the extent of discrediting the advantages of West Point training. This, however, has not been the case; the most successful of leaders who had come up 'from the ranks' have united in deploring for themselves the lack of certain elements, hardly to be described and to be gained only in early youth, and to advocate most strenuously the training that the academy affords.

This influence, which has been quite unanimous, combined with the popular feeling consequent upon our sudden rise as a 'world-power,' has determined congress to increase largely the capacity of West Point, and to remodel wholly the *material* of the institution. For this pur-



THE CHAPEL.

pose the sum of five million dollars has been appropriated, and, after a competition between ten prominent firms of architects, the award of excellence in general design has been made to Cram, Goodhue and Ferguson, of Boston.

The work of remodeling the academy is necessarily tri-fold: it naturally resolves itself into the architectural, the pictorial, and, inevitably, the practical. At present the buildings of the academy, constructed as they have been at various periods and by authority of men of various degrees of artistic feeling, are more or less ill-assorted and incongruous; several are fine examples of architecture; the cadet barracks highly appropriate in treatment, and the cadet mess-hall

exquisitely designed. But—not to be invidious—at least, there are 'others.' The Cullum Memorial building is quite worthy in its way and standing alone; but its Polonian fairness serves only to 'swear at' the grim granite, buttressed and embattled, across the plain. By the side of the Memorial (as if it had laid an egg) is the officers' mess—that also not bad architecturally, but a little, just a little, one feels, out of keeping. The hotel, of course, is a bad blot on the landscape, and some other matters need remedying. Let us be patient as well as brutally frank—they are all going to be remedied if the government will permit the architects to 'build up the system.'

No mere panaceas for the accident of incongruity; touches here and there modifying or obscuring or obliterating something hideous or something merely obtrusive, saving sacredly all that can or ought to be saved out of the chaos; never replacing anything really beautiful by something even more beautiful even to propitiate uniformity, and above all guarding jealously the spirit of old associations, always at 'arms-port' to cry, 'Who comes there?' to him—even to a friend, without the academy or within, who can not give the countersign, 'Propriety,' or seeks to substitute 'Utility.'

What a superb foundation these artist souls may build upon! A level square mile, terre-plein whose barbette views throw glances riverward many miles north and south, a steep scarp of primeval rock plunging down sheer to the glacis of water below; outlying works of precipitous hills, piled terrace upon terrace to the highest peak crowned with the gray vestiges of Fort Rufus Putnam.

Not alone the traditions of the military academy invite the artisan and the architect to his best efforts, but here are older historic associations yet to stimulate also the poet. To the planning of such work as is here contemplated some measure of fine frenzy must mingle with the dull prosaic details of necessity or expediency.

The general plans and such details as have been elaborated show conclusively how grand the scope of alteration, how admirably existing conditions are to be utilized, and the natural features are to be availed of. In its material phases West Point may be easily separated into three distinct periods: that of the early academy, of the old north and south barracks—of the academy as it was when Edgar Allan Poe was a cadet, where Whistler stood higher in drawing than in chemistry, and where Grant and Lee, Sherman and Longstreet got their education. Then came the time of the present barracks, Elizabethan, stately, well appointed. It was erected in 1851. The old academic building was built in 1838, and was replaced by the present modern structure in or about 1890. The third period is that about to be inaugurated.

In the construction of the New West Point the present academic building will be retained; the site of the old chapel being utilized for

additional academic accommodations; the new chapel—decidedly the most ornate and conspicuous of the new buildings—lifted upon a spur of the hills overlooking the plain. The barracks also will be kept, with material additions and changes needed for the housing of the increased number of cadets. To the north of the Cullum Memorial and balancing the officers' mess-hall will be located a building for use as bachelors' quarters, of the same Georgian style of architecture.

The enmity of styles, as far as possible, will be propitiated, one blending with the other, without actually mingling, masses of foliage serving to keep a measure of peace between them. Where the hotel now stands it is proposed to erect the quarters of the superintendent, the present battle monument duplicated on the right of what may be termed the major axis of the scenic system. The avenue now existing vistas upon the center of academic life, while other avenues will be made to radiate from here, across the plain, sweeping down the hillside.

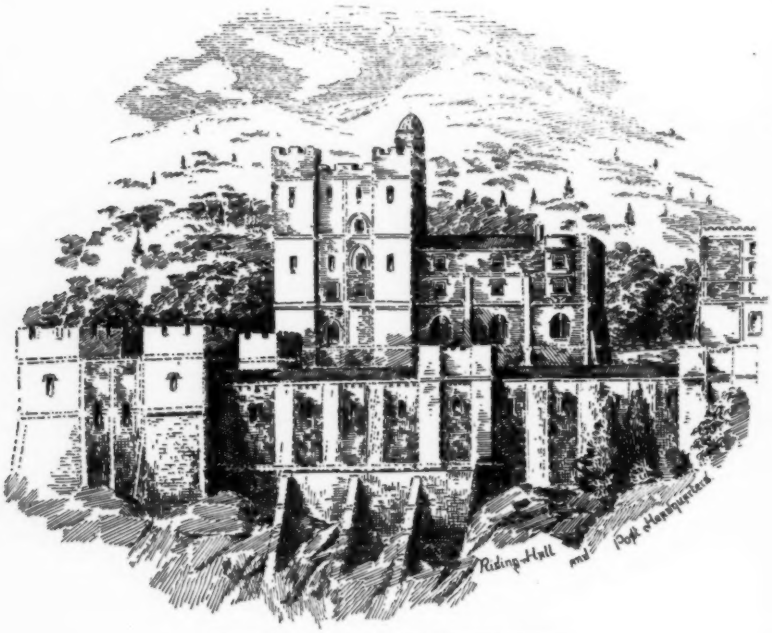
The approach to the academy will probably be completely altered; the landing either from railway or boats being made not only commodious but imposing. Access to the high level will be as now by means of a gently winding ramp, while a large passenger elevator will conduct to a public square, to the restaurant and hotel; these being located where they will be apart from the real activities of either academic or military life, and yet conducing more readily to the convenience and comfort of visitors. From the south, the post will be approached through elaborate arched gateways, with appropriate towers, the strongest emphasis being placed upon this prime avenue, while between the two sections of the academy will be a monumental arch, to be adorned with statues and memorials.

As seen from the river the riding-hall, greatly enlarged, will be the most imposing of structures, rising as it will from the perpendicular crags, growing out of them and seeming a part of them, buttressed on front and flank and crowned with a line of battlements. Above will rise the fine elevation of the post headquarters, which will form also a striking background from the southern approach.

The dominant style of the construction will be the Gothic, not American architecture as it has grown pliant and flexible from the studiously archeological, but suggestive of the ascendant impulses of formality of former British models. The material will be generally stone, treated with greater or less elaboration, according to the value pictorially of the buildings, due harmony being preserved or achieved by judicious alterations in effect. Several of the minor structures will be of red brick in Flemish bond, trimmed with stone.

Perhaps the most difficult problem was that of the judicious enlargement of the cadet barracks, to accommodate double or more the

number of cadets for which the present barracks was built. The difficulty was the greater because of the limited space apparently at command. The steep hill on the south seemed an obstacle to additions in that direction, while the gymnasium on the west occupied ground that could otherwise have been used. Previous to the submission of the work to competition, there was a studied examination of the entire subject of enlargement by a board of officers detailed for the purpose, and one of the professors at the academy—Professor Larned of the department of drawing—made a special study and comprehensive re-



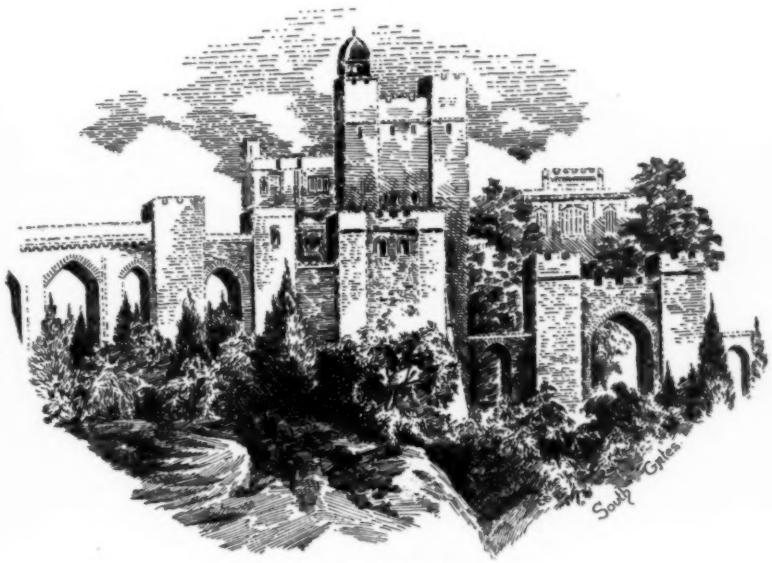
RIDING HALL AND POST HEADQUARTERS.

port. Among the officers there was developed considerable difference of opinion and these divergent views have been set forth in a majority and minority report. The enlargement of barracks was a point upon which the difference of views was especially pronounced; in effect the problem that the architects were called upon to solve was, or seemed to be, solely to decide whether the barrack buildings should be extended on a line parallel to the west side of the plain, or whether a closed quadrangle should be formed by a series of so-called divisions south of the present sally-port and upon the line now that of the southerly side of the 'area-of-barracks.'

The successful architects, adopting neither of these suggestions, have happily (at least so it seems to an old graduate) hit upon an expedient by which all the advantage of expansion is gained, and with-

out loss—even much gain in the way of structural effect. Practically the present barrack building is left intact, a few simple exterior changes excepted, the advantage of a spacious quadrangle is retained, while sufficient dormitories, light, airy and well swept by prevailing breezes, are provided. Instead of the present inadequate lodging an administration building is planned, not only serviceable but calculated to increase greatly the effect of unity with variety.

In the comprehensive system thus designed, the requirements of the future have not been unheeded. The probabilities of still greater



SOUTH GATES.

expansion than any now contemplated sedulously and with rare judgment have been pointed out. By the removal of the gymnasium to another suitable locality, the barracks could be prolonged to the westward, furnishing quarters for nearly three hundred more cadets in addition to the present large increase in the corps; the natural amphitheater at the foot of the hill back of the line of professors' quarters on the plain suggests the erection of a stadium for athletics—baseball, cricket, football and the like. The natural slope could there easily be so managed as to give seating for six thousand spectators. The removal of the cavalry and artillery ground to the southerly end of the reservation was recommended by the officers' board, and this feature will be incorporated in the design.

It is not to disparage the earnest efforts of preceding administrations of either the academy or the war department to say that heretofore little has been done in the way of symmetry of proportion or in

fact of even enlightened systematic utility. Such flagrant solecisms of economy as that the post quartermaster's offices, the post office and the meat market should be huddled together in the same vicinity, will now be completely remedied. Hitherto appropriations have been too limited in amount and too rigidly doled out in detail by civilian 'watch dogs' of trivial parsimonies. Now at last the way seems tolerably clear by which the several functions of the post shall be grouped in order of the importance: first, that which is military, afterwards, and adjoining, that which is scholarly, and then, separate and apart, all other and subsidiary functions—supplying and purveying of goods, reception and entertaining of guests; all will be no longer scattered or occupying the most eligible positions, but grouped together and in exactly their right locality.

The plans as already outlined are in scope and arrangement as nearly perfect as practical ingenuity could devise. It is greatly to be hoped that in carrying out so thorough a reformation, they who are charged with the duty may remain unhampered by an authority supreme in the state, but which has in manifold instances in the past proved its woeful incapacity to deal with technical needs or more deplorably yet, with the demands of art. The mistake at Annapolis will probably not be here repeated; but the New West Point will be made to burgeon out of the old; the revolutionary relics retained with all their hallowed associations unimpaired, and the sacred traditions of the academy held inviolate.

A LABORATORY FOR THE STUDY OF MARINE ZOOLOGY IN THE TROPICAL ATLANTIC.*

By Dr. ALFRED GOLDSBOROUGH MAYER.

MANY able naturalists have discussed the question of the advisability of establishing a marine biological laboratory for research within the West Indian region, and the advocacy of the idea by Huxley and Lancaster is a matter of recent memory. While none of these discussions has resulted in the establishment of a permanent laboratory they have served a useful purpose in keeping alive the interest of

Track of Loggerhead Turtle (*T. caretta*) made in crawling up the Beach to lay its Eggs. Loggerhead Key, Tortugas.

biologists, and also in proving that it is very difficult to bring about a combination of colleges or learned societies which will lead to the establishment of such a station.

Indeed the realization of the establishment of such a laboratory might be considered well-nigh hopeless were it not for the recent creation of the Carnegie Institution. If it be the aim of this institution to maintain researches which no existing agencies have been able to

* With illustrations by permission of the Museum of the Brooklyn Institute of Arts and Sciences.

perform it would appear that an excellent opportunity is presented in the possibility of establishing such a laboratory.

Each of our universities and learned societies represents a more or less well-defined and consequently narrow clientage, while the Carnegie Institution alone is truly national in its scope and influence. Also while our national scientific bureaus must devote their energies chiefly to the solution of practical problems, the Carnegie Institution alone may devote even the major proportion of its funds to the advancement of pure science. As no permanent laboratory for research in marine zoology exists in the West Indian region the Carnegie Institution would have an absolutely free hand in determining the situation, scope and destiny of such a station.

NODDY GULL (*A. stolida*) UPON ITS NEST, BIRD KEY, TORTUGAS, WHERE SEVERAL THOUSAND OF THESE BIRDS NEST ANNUALLY.

The present movement appears to have been initiated by two articles in *Science* advocating the establishment of such a laboratory at the Tortugas, Florida. Considerable discussion ensued; the chief questions being those of the most suitable site for the station, its auspices, and the character of its work. Opinions upon these important points were expressed by fifty naturalists, such as Barton, M. A. Bigelow, R. P. Bigelow, Chapman, H. L. Clarke, J. F. Clarke, Conklin, Dall, Davenport, Dean, Dodge, Duerden, Edwards, Evermann, Gill, Hargitt, Herrick, L. O. Howard, Jennings, H. P. Johnson, D. S. Jordan, V. L. Kellogg, Kingsley, Lillie, Lucas, McBride, McMurrich, Metcalf, Mills, Minot, Montgomery, Morgan, Neal, Nutting, Ortmann, C. H. Parker, R. Rathbun, Richards, Ritter, Rolfs, Sedgwick, Springer, R. M. Strong, Treadwell, Verrill, H. B. Ward and four others. It is evident that a large number of our most active biologists have interested themselves in the project.

Twenty of those who have expressed any opinion upon the question of site have favored more or less strongly the placing of the laboratory at the Tortugas; six recommend Jamaica; three Porto Rico; two the Gulf Coast; two the Bahamas; the Isle of Pines, Miami, Florida, and the Bermudas each one.

Although the number of naturalists who have advocated the placing of the laboratory at Jamaica is small, their opinion is evidently worthy

of highest respect when we consider that among them are such investigators as Barton, H. L. Clark, Conklin, Duerden and Morgan. The advantages claimed for Jamaica are a healthful climate, the best of social conditions, a rich *land* and *fresh-water* as well as marine fauna and flora, and the accessibility of the island. The land flora and fauna of Jamaica are stated on good authority to be the richest of the Antilles, while the coral reefs and marine fauna, although possibly

THE PARADE GROUND OF FORT JEFFERSON, DRY TORTUGAS, SEEN THROUGH ONE OF THE CASEMATES.

not so rich as those of the Tortugas, are said to be remarkably varied. Unfortunately none of the gentlemen who advocate Jamaica have been at the Tortugas, and it is therefore impossible for them to make any direct comparison between the marine faunæ of the two places.

The advocates of the Tortugas, Florida, claim that here we find by far the *richest pelagic fauna* of the tropical Atlantic which is driven upon the shores by the prevailing winds from the Gulf Stream.

The Tortugas reefs, while not so rich in corals, are richer in fishes and invertebrates than are those of the Bahamas and probably of other West Indian Islands. The nearness of the Pourtales plateau would give the station an enviable opportunity for deep-sea dredging, while the remarkable purity of the ocean water surrounding the Tortugas would provide the laboratory with an almost unique advantage in the rearing of larvæ, and prosecution of physiological work. The Tortu-

gas is now a naval coaling station, and a naval surgeon is stationed at Fort Jefferson, which is in telegraphic connection with Key West. A large naval tug makes two regular trips each week to and fro between Key West and the Tortugas, completing the journey in less than six hours. The climate is rendered cool by the small land area and the almost constant breeze. There are no sand flies and practically no mosquitoes on Bird and Loggerhead keys, while the few mos-

GULF-WEED AND MARINE ANIMALS CAST UPON THE BEACH OF LOGGERHEAD KEY, TORTUGAS, BY A GALE OF SEVEN HOURS' DURATION.

quitoes at Fort Jefferson could be eradicated by screening the cisterns. The quarantine station has been removed, and the place is most healthful on account of its isolation.

With the exception of several species of gulls, numerous migrating birds and a few insects, the land fauna of the Tortugas is uninteresting, and the flora is limited to the few plants which can cling to beaches of coral sand. In these respects Jamaica is incomparably superior to the Tortugas. The social conditions, and opportunity for the study of a diversified land and fresh-water fauna and flora in Jamaica are far superior to those which may be enjoyed at the Tortugas. On the other hand, the Tortugas has a far richer pelagic and certainly equally good littoral fauna, the purest of ocean water, and it affords the best situation in the world from which to study the life and conditions of the Gulf Stream. To students from the middle west the Tortugas are more accessible than is Jamaica.

The discussion has at least succeeded in establishing the fact that the Bahamas are on the whole inferior to the Tortugas, for despite their good coral reefs, their pelagic and littoral faunæ are relatively poor. Nutting who directed one of the most successful biological expeditions ever sent to the Bahamas, is emphatic in declaring the superiority of the Tortugas. The prevalent winds prevent the floating life of the Gulf Stream from reaching the Bahamas, whereas they con-

THE QUEEN'S STAIRWAY, NASSAU, BAHAMAS. A cut through æolian rock.

stantly drift the pelagic creatures of the stream upon the Tortugas.

Next to Jamaica, Porto Rico appears to be the favorite among the Antilles; the southern shore, Mayaguez, and Culebra Island being especially recommended. Judging from the published results of the *Fish Hawk* expedition of 1898–99 under the auspices of the United States Fish Commission, the littoral fauna is remarkably good, although I am informed on excellent authority that the pelagic hauls of the expedition were poor. The social conditions of Porto Rico appear to be not so good as those of Jamaica, and its land fauna and

flora are said to be poorer than those of the English island, but there are certain advantages in having the station established upon land possessed by the United States. This also applies to the Isle of Pines, which has been ably recommended by J. Fred Clarke.

The marine fauna of the Tortugas is greatly superior to that of the Florida mainland or Gulf Coast. Moreover, while the ocean water surrounding the Tortugas is of the purest the shore waters of Florida and the Gulf of Mexico are often charged with silt, and sullied with the drainage from mangrove swamps to such a degree as to be rapidly fatal to pelagic life. The littoral fauna of the mainland shores is

BEACH ROCK AT MASTIC POINT, ANDROS ISD., BAHAMAS. A typical sea-worn rocky beach composed of agglutinated fragments of shells, corals, etc.

inferior to that of the Tortugas, and the greater heat, mosquitoes and occasional epidemics of mainland places render them undesirable.

The fauna of Bermuda is subtropical and consequently poorer than that of the Bahamas, Tortugas or West Indies. Judging from the results accomplished by Fewkes and others the pelagic life appears to be even poorer than that of the Bahamas, although the expeditions under Verrill have demonstrated that the littoral fauna is very rich.

Summing up, the question of site appears to have been narrowed down to a choice between the Tortugas and one of the Antilles, the favorite island being Jamaica. Before this question can be definitely settled some competent naturalist who is already familiar with the fauna and flora of one of these places should investigate the other with a view to drawing a just comparison between them. It is remarkable

that no biologist familiar with either one of these situations has ever studied at the other.

Concerning the scope and auspices of the laboratory all the correspondents are agreed that it should be national in character, and that every possible aid should be given to all competent students, both in the prosecution of their studies and in the *publication of results.*

Although a tropical laboratory may well remain open during the entire year, the most available months for study are May 1 to August 1. This is the period of calms, which follows the trade wind period of the winter and precedes the hurricane season of the autumn. During late spring and early summer months one may safely go out to sea in small sail boats, and may wade and collect on the windward sides of the reefs, an advantage rarely enjoyed during the winter, when the almost constant trade wind lashes the ocean into foam. There is yet another advantage gained by selecting the summer months for study, for this is the period when numerous larvæ and young forms appear; and few realize who have not been there that there is almost as much difference between the faunæ of summer and winter in the tropical ocean as there is along our own temperate shores. With the exception of the Siphonophoræ, almost all forms of pelagic life are much more numerous in spring and summer than during the winter months. These remarks apply especially to the Tortugas and Bahamas, where the calm period is well marked.

This appeal for this laboratory may seem to some to be worthy of but little attention; for abstract laws and facts having little or no bearing upon the practical things of life would chiefly concern its thought, but who may dare to predict the outcome of the study of pure science? Polarized light by means of which we now analyze our sugars, the principles underlying the working of the dynamo, telegraph and telephone; the great law of evolution and the germ theory of disease were all discovered and made known by men who had in mind only the advancement of the sum of human knowledge totally apart from practical results or the acquisition of wealth. Our national progress vast in material has been insignificant in abstract science, yet underlying all practical applications are the laws which men who have studied nature for the simple love of her ways have found. Too much of our energy is withdrawn from the study of cardinal principles, and too much devoted to the application of established laws to the serving of mere practical ends. Let us have at least one laboratory devoted exclusively to *research* in science, both pure and applied, and let its course be free from criticism if it be so fortunate as to lead to the discovery of laws even if no money be made thereby.

THE PARENT-STREAM THEORY OF THE RETURN OF SALMON.

By President DAVID STARR JORDAN,
LELAND STANFORD JUNIOR UNIVERSITY.

IT has been generally accepted as unquestioned, by packers and fishermen, that the salmon of the Pacific (king salmon, red salmon, silver salmon, humpback salmon and dog salmon) all return to spawn to the very stream in which they were hatched. As early as 1880, the present writer placed on record his opinion that this theory was unsound. In a general way, most salmon return to the parent stream, because when in the sea the parent stream is the one most easily reached. The channels and runways which directed their course to the sea may influence their return trip in the same fashion. When the salmon is mature, the spawning season approaching, it seeks fresh water. Other things being equal, about the same number will run each year in the same channel. With all this, we find some curious facts. Certain streams will have a run of exceptionally large or exceptionally small red salmon. The time of the run bears some relation to the length of the stream: those who have farthest to go start earliest. The time of running bears also a relation to the temperature of the spawning grounds—where the waters cool off earliest, the fish run soonest.

The supposed evidence in favor of the parent stream theory may be considered under three heads:* (1) Distinctive runs in various streams, (2) return of marked salmon, (3) introduction of salmon into new streams followed by their return.

Under the first head it is often asserted of fishermen that they can distinguish the salmon of different streams. Thus the Lynn Canal red salmon are larger than those in most waters, and it is claimed that those of Chilcoot Inlet are larger than those of the sister streams at Chilcat. The red salmon of Red Fish Bay on Baranof Island (near Sitka) are said to be much smaller than usual, and those of the neighboring Necker Bay are not more than one third the ordinary size. Those of a small, rapid stream near Nass River are more wiry than those of the neighboring large stream. The same claim is made for the different streams of Puget Sound, each one having its characteristic run. In all this there is some truth and

* See an excellent article by H. S. Davis in the *Pacific Fisherman* for July, 1903.

perhaps more exaggeration. I noticed that the Chilcoot fish seemed deeper in body than those at Chilcat. The red salmon becomes compressed before spawning, and the Chilcoot fishes having a short run spawn earlier than the Chilcat fishes, which have many miles to go, the water being perhaps warmer at the mouth of the river which flows farthest from the parent ice-fields. The riper fishes run up the shorter river. In Bristol Bay, according to Dr. Gilbert, the great runs ascend sometimes one river, sometimes another. Perhaps some localities may meet the nervous reactions of small fishes while not attracting the large ones. In Necker Bay a few full-grown salmon run besides the little ones. A few dwarf individuals, two and three year olds, ripened prematurely, run in every salmon stream. These little fishes are nearly all males. Mr. H. S. Davis well observes that 'until a constant difference has been demonstrated by a careful examination of large numbers of fish from each stream taken *at the same time*, but little weight can be attached to arguments of this nature.'

It is doubtless true as a general proposition that nearly all salmon return to the region in which they were spawned. Most of them apparently never go far away from the mouth of the stream or the bay into which it flows. It is true that salmon are occasionally taken well out at sea and it is certain that the red salmon runs of Puget Sound come from outside the Straits of Fuca. There is, however, evidence that most species rarely go so far as that. When seeking shore, they usually reach the original channels.

In 1880, the writer, studying the king salmon of the Columbia, used the following words, which he has not had occasion to change:

> It is the prevailing impression that the salmon have some special instinct which leads them to return to spawn in the same spawning grounds where they were originally hatched. We fail to find any evidence of this in the case of the Pacific coast salmon, and we do not believe it to be true. It seems more probable that the young salmon hatched in any river mostly remain in the ocean within a radius of twenty, thirty or forty miles of its mouth. These, in their movement about in the ocean may come into contact with the cold waters of their parent rivers, or perhaps of any other river, at a considerable distance from the shore. In the case of the quinnat and the blueback, their 'instinct' seems to lead them to ascend these fresh waters, and in a majority of cases these waters will be those in which the fishes in question were originally spawned. Later in the season the growth of the reproductive organs leads them to approach the shore and search for fresh waters, and still the chances are that they may find the original stream. But undoubtedly many fall salmon ascend, or try to ascend, streams in which no salmon was ever hatched. In little brooks about Puget Sound, where the water is not three inches deep, are often found dead or dying salmon, which have entered them for the purpose of spawning. It is said of the Russian River and other California rivers, that their mouths, in the time of low water in summer, generally become entirely closed by sand-bars, and that the salmon, in their eagerness to ascend them, frequently fling themselves entirely out of water on the beach. But this does

not prove that the salmon are guided by a marvelous geographical instinct which leads them to their parent river in spite of the fact that the river can not be found. The waters of Russian River soak through these sand-bars, and the salmon instinct, we think, leads them merely to search for fresh waters. This matter is much in need of further investigation; at present, however, we find no reason to believe that the salmon enter the Rogue River simply because they were spawned there, or that a salmon hatched in the Clackamas River is more likely, on that account, to return to the Clackamas than to go up the Cowlitz or the Des Chûtes.

Attempts have been made to settle this question by marking the fry. But this is a very difficult matter, indeed. Almost the only structure which can be safely mutilated is the adipose fin, and this is often nipped off by sticklebacks and other meddling fish. The following experiments have been tried, according to Mr. Davis:

In March, 1896, 5,000 king salmon fry were marked by cutting off the adipose fin, then set free in the Clackamas River. Nearly 400 of these marked fish are said to have been taken in the Columbia in 1898 and a few more in 1899. In addition a few were taken in 1898, 1899 and 1900 in the Sacramento River, but in much less numbers than in the Columbia. In the Columbia most were taken at the mouth of the river where most of the fishing was done, but a few were in the original stream, the Clackamas. It is stated that the fry thus set free in the Clackamas came from eggs obtained in the Sacramento—a matter which has, however, no bearing on the present case.

In the Kalama hatchery on the Columbia River, Washington, 2,000 fry of the quinnat or king salmon were marked in 1899 by a V-shaped notch in the caudal fin. Numerous fishes thus marked were taken in the lower Columbia in 1901 and 1902. A few were taken at the Kalama hatchery, but some also at the hatcheries on Wind River and Clackamas River. At the hatchery on Chehalis River six or seven were taken, the stream not being a tributary of the Columbia, but flowing into Shoalwater Bay. None were noticed in the Sacramento. The evidence shows that the most who are hatched in a large stream tend to return to it, and that in general, most salmon return to the parent region.

There is no evidence that a salmon hatched in one branch of a river tends to return there rather than to any other. Experiments of Messrs. Rutter and Spaulding in marking adult fish at Karluk would indicate that they roam rather widely about the island before spawning. A spawning fish set free in Karluk River was found three days later at Red River, sixty miles away on the opposite side of Kadiak Island.

The introduction of salmon into new streams may throw some light on this question. In 1897 and 1898, 3,000,000 young king salmon fry were set free in Papermill Creek near Olema, California. This is a small stream flowing into the head of Tomales Bay, and it had never previously had a run of salmon. In 1900, and especially in 1901, large quinnat salmon appeared in considerable numbers in this stream. One specimen weighing about sixteen pounds was sent to the present writer for identification. These fishes certainly returned to

the parent stream, although this stream was one not at all fitted for their purpose.

But this may be accounted for by the topography of the Bay. Tomales Bay is a long and narrow channel, about twenty miles long and from one to five in width, isolated from other rivers, and with but one tributary stream. Probably the salmon had not wandered far from it; some may not have left it at all. In any event, a large number certainly came back to the same place.

That the salmon rarely go far away is fairly attested. Schools of king salmon play in Monterey Bay, and others chase the herring about in the channels of southeastern Alaska. A few years since, Captain J. F. Moser, in charge of the *Albatross,* set gill nets for salmon at various places in the sea off the Oregon and Washington coast, catching none except in the bays.

Mr. Davis gives an account of the liberation of salmon in Chinook River, which flows into the Columbia at Baker's Bay:

> It is a small, sluggish stream and has never been frequented by Chinook salmon, although considerable numbers of silver and dog salmon enter it late in the fall. A few years ago the state established a hatchery on this stream, and since 1898 between 1,000,000 and 2,000,000 Chinook fry have been turned out here annually. The fish are taken from the pound-nets in Baker's Bay, towed into the river in crates and then liberated above a dike which prevents their return to the Columbia. When ripe, the salmon ascend to the hatchery, some two or three miles further up the river where they are spawned.
>
> The superintendent of the hatchery, Mr. Nic Hansen, informs me that in 1902, during November and December, quite a number of Chinook salmon ascended the Chinook River. About 150 salmon of both sexes were taken in a trap located in the river about four miles from its mouth. At first thought it would appear that these were probably fish which, when fry, had been liberated in the river, but unfortunately there is no proof that this was the case. According to Mr. Hansen, the season of 1902 was remarkable in that the salmon ran inshore in large schools, a thing which they had not done before for years. It is possible that the fish, being forced in close to the shore, came in contact with the current from the Chinook River, which, since the stream is small and sluggish, would not be felt far from shore. Once brought under the influence of the current from the river the salmon would naturally ascend that stream, whether they had been hatched there or not.

The general conclusion, apparently warranted by the facts at hand, is that the Pacific salmon, for the most part, do not go to a great distance from the stream in which they are hatched, that most of them return to the streams of the same region, a majority to the parent stream, but that there is no evidence that they choose the parental spawning grounds in preference to any other, and none that they will prefer an undesirable stream to a favorable one for the reason that they happen to have been hatched in the former.

Mr. John C. Callbreath, of Wrangel, Alaska, has long conducted a very interesting but very costly experiment in this line. About

1890, he established himself in a small stream called Jadgeska on the west coast of Etolin Island, tributary to McHenry Inlet, Clarence Straits. This stream led from a lake, and in it a few thousand red salmon spawned, besides multitudes of silver salmon, dog salmon and humpback salmon. Making a dam across the stream, he helped the red salmon over it, destroying all the inferior kinds which entered the stream. He also established a hatchery for the red salmon, turning loose many thousand fry each year for about twelve years. This was done in the expectation that all the salmon hatched would return to Jadgeska in about four years. By destroying all individuals of other species attempting to run, it was expected that these would become extinct so far as the stream is concerned.

The result of this experiment has been disappointment. After twelve years or more there has been no increase of red salmon in the stream, and no decrease of humpbacks and other humbler forms of salmon. Mr. Callbreath draws the conclusion that salmon run at a much greater age than has been supposed—perhaps at the age of sixteen years, instead of four. A far more probable conclusion is that the salmon set free by him have joined other bands bound for more suitable streams. It is indeed claimed that since the establishment of Callbreath's hatchery on Etolin Island, there has been a notable increase of the salmon run in various streams of Prince of Wales Island on the opposite side of Clarence Straits. But this statement, while largely current among the cannerymen, and not improbable, needs verification.

We shall await with much interest the return of the millions of young salmon hatched in 1902, and turned loose in Naha stream. We may venture the prophecy that while a large percentage will return to Loring, many others will enter Yes Bay, Karta Bay, Moira Sound and other red salmon waters along the line of their return from Dixon Entrance or the open sea.

HERTZIAN WAVE WIRELESS TELEGRAPHY. VI.

By Dr. J. A. FLEMING, F.R.S.,
PROFESSOR OF ELECTRICAL ENGINEERING, UNIVERSITY COLLEGE, LONDON.

It remains then to consider some of the questions connected with practical Hertzian wave telegraphy and the problem of the limitation of communication. These matters at the present moment very much occupy the public attention, and many conflicting opinions are expressed concerning them.

It may be observed at the outset that the difficulty of dealing with the subject as freely as many desire is that Hertzian wave telegraphy is no longer merely a subject of scientific investigation, but has developed into a business and involves therefore other interests than the simple advancement of scientific knowledge. We can, however, discuss in a general manner some of the scientific problems which present themselves for solution. The first of these is the independence of communication between stations. It is desirable, at the outset, to clear up a little misunderstanding. There is a great difference between preventing the reception of communication when it is not desired by the recipient and preventing it when it is the object of the latter to overhear if he can. It is therefore necessary to distinguish between isolation and overhearing. We may say that a station is *isolated* when it is not affected by Hertzian waves other than those it desires to receive; but that a station *overhears* when it can, if it chooses, pick up communications not intended for it, or can not help receiving them against its will.

This distinction is a perfectly fair one. Any telegraph or telephone wire can be tapped, if it is desired, but unless there is some fault on the line, no station will receive a message against its desires. Moreover, it may be noted that there are penalties attaching to tapping a telegraph wire, and at present there are none connected with the misappropriation of an ether wave.

We shall therefore consider in the first place the methods so far proposed for preventing any given receiver from being affected by Hertzian waves sent out from other stations, except that of those from which it is desired to receive them. The first method is that which has been called the method of *electrical syntony*, and consists in adjusting the electrical capacity and inductance of the various open and closed

circuits of the receiving and transmitting stations to be put in communication so that they have the same electrical time-period.*

In the Cantor Lectures before the Society of Arts in 1900, on electrical oscillations and electric waves, the author has discussed at length the conditions under which powerful electrical oscillations can be set up in a circuit. It was there shown that every electric circuit having capacity and inductance has a particular or natural time-period of electrical oscillation depending on the product of these qualities, and that, to accumulate powerful electrical oscillations in it, the electromotive impulses on it must be delivered at this rate. Illustrations were drawn from mechanics, such as the examples furnished by vibrating pendulums and springs, and from acoustics, as illustrated by the phenomena of resonance, to show that small or feeble blows or impulses delivered at the proper time intervals have a cumulative effect in setting up vibrations in a body capable of oscillation. It is a familiar fact that if we time our blows, we can achieve that which no single blow, however powerful, can accomplish in throwing into vibration a body such as a pendulum, which is capable of oscillation under the action of a restoring force. Precisely the same is true of an electric circuit. We have already seen that the receiving aerial has an alternating electromotive force set up in it by the impact of the successive electric waves sent out from the transmitter. It must, however, be remembered that the transmitter sends out a series of trains of waves, not by any means a continuous train, but one cut up into groups of probably ten to fifty waves, each separated by intervals of silence, long, compared with the duration of a single train of waves.

If, however, by a suitable adjustment of capacity and inductance, we make the natural time-period of oscillation of the receiving aerial circuits agree with those of the transmitting aerial, within certain limits the former will only be receptive for waves of the frequency sent out by the transmitter. It is quite easy to illustrate this principle by numerous experiments. It can be done by means of an apparatus devised by Dr. Georg Seibt for showing in an interesting manner the syntonization or tuning of two electric circuits. This consists of two bobbins, each consisting of one layer of insulated wire wound on a wooden rod (see Fig. 22). Each of these bobbins has a certain electrical capacity with respect to the earth, when considered as an insulated conductor, and it has also a certain inductance. If therefore electromotive impulses are applied to one end of the bobbin at regular intervals, electrical oscillations will be set up in it, and, as already explained, if these are

* The capacity of an electrical circuit corresponds to the elastic pliability, or what is commonly called the elasticity, of a material substance, and the inductance to mass or inertia. Hence capacity and inductance are qualities of an electric circuit which are analogous to the elasticity and inertia of such a body as a heavy spring.

timed at a certain rate, the bobbin will act like a closed organ pipe to air impulses and oscillations of potential will be accumulated at the opposite end, which have much greater amplitude than the impressed oscillations at the end at which they are applied. We can make the existence of the amplitude oscillations of potential evident by attaching to one end of the bobbin a vacuum tube, which will be illuminated thereby, or by terminating it by a pointed piece of wire, so that an electrical brush can be formed at the point, if the potential variations have sufficient amplitude. We arrange also another closed oscillation circuit consisting of two Leyden jars and a variable inductance coil and a pair of spark balls which are connected to an induction coil. In this manner we can set up oscillations in the discharge circuit of these Leyden jars, and we can vary the time period by altering the inductance and the capacity. If we denote the capacity of the jars in the microfarads by the letter C and the inductance in centimeters of the discharge circuit of the jars by the letter L, it can then be shown that the number of oscillations per second denoted by n is given by the expression:*

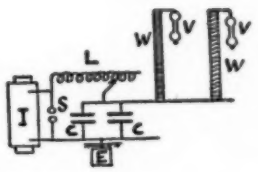


FIG. 22. SEIBT'S APPARATUS FOR EXHIBITING ELECTRIC RESONANCE. *I*, induction coil; *S*, spark gap; *CC*, condensers; *L*, variable inductance; *E*, earth plate; *WW*, wire spirals; *VV*, vacuum tubes.

$$n = \frac{5{,}000{,}000}{\sqrt{CL}}.$$

If now we adjust the Leyden jar circuit to a particular rate of oscillation, we have between the terminals of the jar or condenser an alternating difference of potential or electromotive force. If we connect one side of the jars to the earth and the other side to the foot of one of the spirals or bobbins above described, we shall find perhaps that the vacuum tube at the other end is not rendered luminous. When, however, we adjust the inductance in the discharge circuit of the jar to a certain value to make the frequency of the condenser oscillations agree with the natural time period of the bobbin terminated by the vacuum tube, this latter at once lights up brilliantly. Again, if we connect both these bobbins at the same time to the discharge circuit of the Leyden jar, we shall find that we can make an adjustment of the inductance of that circuit, such that either of the bobbins at pleasure can be made to respond and be set in electrical vibration, as shown by the illumination of the vacuum tube at its upper end or by an electrical

* See Cantor Lectures, on 'Electrical Oscillations and Electric Waves,' delivered before the Society of Arts, London, November 26, December 4, 10, 17, 1900. Lecture I., page 12, of reprint.

brush being formed at the terminal. In making this adjustment of inductance, we are *tuning*, as it is called, the Leyden jar discharge circuit to the resonating bobbin. A very small variation of the inductance of the jar circuit causes the vacuum tube to change in luminosity. If, however, the natural time periods of these bobbins do not lie very far apart, then a faint luminosity will make its appearance in both the vacuum tubes. Supposing therefore that we connect to the oscillating circuit of the jar a number of bobbins having different time-periods of oscillation, like organ-pipes, and supply them all with one common alternating electromotive force. Those bobbins whose natural time-period is very different to that of the oscillating circuit or impressed electromotive force will not respond, but those bobbins of which the natural time-period lies near to, even if not quite exactly the same as, that of the impressed electromotive force will give evidence of being set in oscillation. A very violent electromotive force will cause them all to respond to some slight extent, no matter whether the period of that impulse is tuned to their common period precisely or not.

At this point questions arise of great practical importance. A matter which has been in dispute in connection with practical Hertzian wave telegraphy is how far this electrical tuning is a sufficient solution of the practical problem of isolation. It is not denied that experiments such as those made with Seibt's apparatus can be shown on a small scale; and, on a still larger scale, Mr. Marconi gave to the author in September, 1900, a demonstration in practical telegraphic work of sending two independent Hertzian wave messages and receiving them on two independent receivers attached to the same aerial.

Since that date much experience has been gained and large power stations erected, and a statement has been frequently made that syntony is no protection against interference when one of the stations is sending out very powerful waves. The contention has been raised that large power stations producing electric waves will therefore play havoc with Hertzian wave telegraphy on a smaller scale, such as the ship to shore and intermarine communication. Under these circumstances, it appeared to the author important to subject the matter to a special test, and Mr. Marconi therefore offered to give a demonstration, with this object, in support of the opinion that he has expressed positively that waves from his power stations do not interfere with the working of his ship installations. This matter is vital to the whole question of practical Hertzian wave telegraphy, for the ship to shore communication is of stupendous importance; and if Mr. Marconi had done nothing else except render this possible and effective, he would have earned, as he has done, the gratitude of humanity for all time. Accordingly, the author embraced the opportunity of making some careful tests to settle the question, whether the powerful waves sent out from a station such as Poldhu did or did not affect the exchange of messages between ship

and shore stations in proximity, equipped with Marconi apparatus of a suitable type.

These experiments were carried out on the eighteenth of March last, at Poldhu, in Cornwall, and a program was arranged by the author of the following kind. Close to the Poldhu station is an isolated mast, which was equipped by Mr. Marconi with a Hertzian wave apparatus, similar to that he places on ships. Six miles from Poldhu is the Lizard receiving station, with which ships proceeding up or down the English Channel communicate. It was arranged that a series of secret messages, some of them in cipher, should be delivered simultaneously at certain known times, both to the power station at Poldhu and to the small adjacent ship station; and it was arranged that these messages should be sent off simultaneously, the operators being kept in ignorance up to the moment of sending as to the nature of the messages. At the Lizard, Mr. Marconi connected two of his receiving instruments to the aerial, one of them tuned to the waves proceeding from the power station at Poldhu, and the other to those proceeding from the small ship station. At the appointed time, these two sets of messages were received simultaneously in the presence of the author, each message being printed down independently on its own receiver; and Mr. Marconi read off and interpreted all these messages perfectly correctly, not having known before what was the message that was about to be sent. In addition to this, precautions were taken to prove that the power station at Poldhu was really emitting waves sufficiently powerful to cross the Atlantic and not being made to sing small for the occasion. To assist in proving this, the messages sent out from the power station were also received at a station at Poole, two hundred miles away, and the assistant there was instructed to telegraph back these messages by wire as soon as he received them. These messages came back perfectly correctly, thus demonstrating that the power station was sending out power waves. The whole program was carried out with the greatest care to avoid any mistakes on the part of the assistants, and provided an absolute demonstration of the truth of Mr. Marconi's assertion that the waves from one of his power stations, such as Poldhu, do not in the least degree interfere with the transmission and reception of messages between ship and shore, effected by means of certain forms of Marconi apparatus for producing and detecting waves of a different wave length.* This complete independence of transmission, however, is entirely due to the employment of a receiving circuit of a certain type in Mr. Marconi's receivers. It does not at all follow that receiving circuit of any kind, even a Marconi receiver not especially arranged, set up in proximity to a power station would not be affected. This,

*A fuller account of these experiments was given by the author in a letter to the London *Times* published on April 14, 1903.

however, is not an important matter. Far more important is it to show, as has been shown, that practically perfect isolation can be achieved if it is desired.

It must be noted, however, that, although the fact that electric circuits have a natural time-period of oscillation of their own is a scientific principle which carries us a considerable way towards a solution of what is called syntonic Hertzian wave telegraphy, it is not in itself alone in every respect an entire solution of the practical problem. The degree to which it is a solution depends to a considerable extent upon the nature of the detecting device, or kumascope, which we are employing. The coherer, or Branly filings tube, has the peculiarity that its passage from a nonconductive to a conductive condition follows immediately when the difference of potential between its ends is made sufficiently great. In other words, if the tube is acted upon by a sufficient electromotive force, it is not necessary that electromotive force should be repeated at intervals to make this particular form of kumascope responsive. Again, if we consider the nature of the oscillations which are sent out from any transmitting aerial, we find that each group of oscillations corresponding to a single spark consists of waves gradually decreasing in amplitude. In other words, the first wave of the group is the strongest, and the decay in amplitude is often very rapid. Supposing, then, we construct a simple receiver consisting of an aerial having inserted in its circuit a sensitive Branly filings tube. Such a receiver is almost entirely non-syntonic; that is to say, it is affected by any wave passing over it which is sufficiently powerful. We may look upon it that if the first wave of the series is sufficiently powerful to affect the kumascope, the conductive change takes place whether or not the first wave is followed by others. Accordingly, it is perfectly certain that if a transmitter is sending out trains of waves of any period, a simple combination of coherer and aerial will be influenced, if it is placed near enough to the transmitter. On the other hand, it is possible to combine a kumascope of a certain type with a receiving aerial and other circuits in such a manner that when the waves that reach it are feeble it shall not respond at all unless those waves have very nearly a time period of a certain value.

At this stage, it may be perhaps well to explain a little in detail what is meant by an easily responsive circuit, and, on the other hand, by an irresponsive circuit, or, as we may call it, a *stiff* circuit. Supposing that we consider an aerial consisting of a simple straight wire having small capacity and small inductance, such a circuit admits of being sent into electrical oscillation, not only by waves of its own natural time-period, but by the sudden application of any violent electromotive impulse. If, on the other hand, we bestow upon the circuit in any way considerable inductance, we then obtain what may be called a stiff or irresponsive circuit, which is one in which electrical oscillations

can be accumulated only by the prolonged action of impulses tuned to a particular period.

A mechanical analogue of this difference may be found in considering the different behavior of elastic bodies to mechanical blows. Take, for instance, a piece of elastic steel and fix the bottom end in a vise. The steel strip may be thrown into vibration by deflecting the upper end. It has, however, a very small mass, and therefore any violent blow or blows, even although not repeated, will set it in oscillation. If, however, we add mass to it by fixing at the other end a heavy weight, such as a ball of lead, and at the same time make the spring stiffer, we have an arrangement which is capable of being sent into considerable oscillation only by the action of a series of impulses or blows which are timed at a particular rate.

Returning then to the electrical problem, we see that in order to preserve a kumascope or wave detector from being operated on by any vagrant wave or waves having a period very different to an assigned period, it must be associated with an electrical circuit of the kind above called a stiff circuit.

We will now consider the manner in which the problem has been practically attacked by Mr. Marconi, Dr. Slaby, Sir Oliver Lodge and others, who have invented forms of receiver and transmitter, which are syntonic or sympathetic to one another.

Some of the methods which Mr. Marconi has devised for the achievement of syntonic wireless telegraphy were fully described by him in a paper read before the Society of Arts on May 17, 1901.*

On referring to his paper, it will be seen that in one form his transmitter consists of an aerial, near the base of which is inserted the secondary circuit of an oscillation transformer or transmitting jigger. One end of this secondary circuit is attached to the aerial and the other end is connected to the earth through a variable inductance coil. The primary circuit of this oscillation transformer is connected in series with a condenser, consisting of a battery of Leyden jars, and the two together are connected across to the spark balls which close the secondary circuit of an induction coil, having the usual make and break key in the primary circuit. Mr. Marconi so adjusts the induction of the aerial and the capacity of the condenser, or battery of Leyden jars, that the two circuits, consisting respectively of this battery of Leyden jars and the primary circuit of the transformer, and on the other hand of the capacity of the aerial and the inductance in series with it, and that of the secondary circuit of the transformer have the same time period. In other words, these two inductive circuits are tuned together. At the receiving end, the aerial is connected in series with a variable inductance and with the primary circuit of another oscillation transformer,

* See *Journal of the Society of Arts*, Vol. XLIX., p. 505. 'Syntonic Wireless Telegraphy,' by G. Marconi.

the second terminal of which is connected to the earth. The secondary circuit of this last oscillation transformer is cut in the middle and is connected to the terminals of a small condenser. The outer terminals of this secondary circuit are connected to the metallic filings tube or other sensitive receiver and to a small condenser in parallel with it (see Fig. 23). The terminals of the condenser which is inserted in the mid-

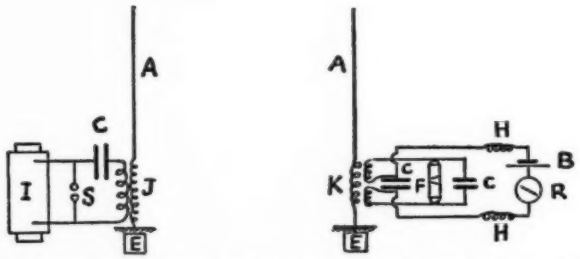


FIG. 23. MARCONI TRANSMITTER AND RECEIVER. *I*, induction coil; *A*, aerial; *E*, earth plate; *HH*, choking coils; *S*, spark gap; *J*, transmitting jigger; *K*, receiving jigger; *R*, relay *C*, condenser; *F*, filings tube; *B*, battery. Many practical details are omitted.

dle of the secondary circuit of the oscillation transformer are connected through two small inductance coils with a relay and a single cell. This relay in turn actuates a Morse printer by means of a local battery. The two circuits of the oscillation transformer are tuned or syntonized to one another, and also to the similar circuit of the transmitting arrangement. When this is the case, the transmitter affects the coresonant receiving arrangement, but will not affect any other similar arrangement, unless it is within a certain minimum range of distance. Owing to the inductance of the oscillation transformer forming part of the receiving arrangements, the receiving circuit is, as before stated, very stiff or irresponsive; the sensitive tube is therefore not acted upon in virtue merely of the impact of the single wave against the aerial, but it needs repeated or accumulated effects of a great many waves, coming in proper time, to break down the coherer and cause the recording mechanism to act. An inspection of the diagram will show that as soon as the secondary electromotive force in the small oscillation transformer or jigger of the receiving instrument is of sufficient amplitude to break down the resistance of the coherer, the local cell in circuit with the relay can send a current through it and cause the relay to act and in turn make the associated telegraphic instrument record or sound.

Mr. Marconi described in the above-mentioned paper some other arrangements for achieving the same result, but those mentioned all depend for their operation upon the construction of a receiving circuit on which the time-period of electrical oscillations is identical with that of a transmitting arrangement. By this means he showed experiments during the reading of his paper, illustrating the fact that two pairs of transmitting and receiving arrangements could be so syntonized that

each receiver responded only to its particular transmitter and not to the other.

With arrangements of substantially the same nature, he made experiments in the autumn of 1900 between Niton, in the Isle of Wight, near Bournemouth, a distance of about thirty miles, in which independent messages were sent and received on the same aerial.

Dr. Slaby and Count von Arco, working in Germany, have followed very much on the same lines as Mr. Marconi, though with appliances of a somewhat different nature. As constructed by the General Electric Company, of Berlin, the Slaby-Arco syntonic system of Hertzian telegraphy is arranged in one form as follows: The transmitter consists of a vertical rod like a lightning conductor, say 100 or 150 feet in height. At a point six or nine feet above the ground, a connection is

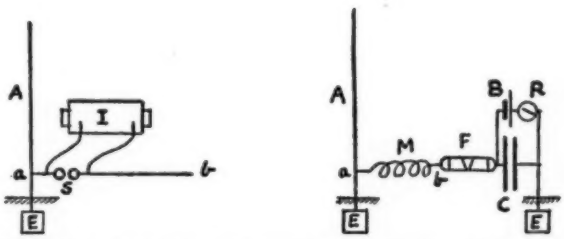


FIG. 24. SLABY-ARCO SYNTONIC TRANSMITTER AND RECEIVER. *I*, induction coil; *M*, multiplier; *B*, battery; *A*, aerial; *F*, filings tube; *R*, relay; *E*, earthplate; *C*, condenser.

made to a spark ball (see Fig. 24), and the corresponding ball is connected through a variable inductance with one terminal of a condenser, the other terminal of which is connected to the earth. The two spark balls are connected to an induction coil, or alternating current transformer, and by variation of the inductance and capacity the frequency is so arranged that the wave-length corresponding to it is equal to four times the length of that portion of the aerial which is above the spark ball connection. The method by which this tuning is achieved is to insert in the portion of the aerial below the spark balls, between it and the earth, a hot wire ammeter of some form. It has already been shown that in the case of such an earthed aerial, when electrical oscillations are set up in it, there is a potential node at the earth and a potential antinode or loop at the summit, if it is vibrating in its fundamental manner; also, there is a node of current at the summit of the aerial and an antinode at the base. This amounts to saying that the amplitude of the potential vibrations is greatest at the top end of the aerial, and the amplitude of the current vibrations is greatest at the bottom or earthed end. Accordingly, the inductance and capacity of the lateral branch of the transmitter is altered until the hot wire ammeter in the base of the aerial shows the largest possible current.

The corresponding receiver is constructed in a very similar manner.

A lightning conductor or long vertical rod of the same height as the transmitting aerial is set up at the receiving station, and at a point six or nine feet from the ground a circuit is taken off, consisting of a wire loosely coiled in a spiral, the length of which is nearly equal to, although a little shorter than, the height of the vertical wire above the point of connection. The outer end of this loose spiral is connected to one terminal of the coherer tube, and the other terminal of the coherer is connected to the earth through a condenser of rather large capacity. The terminals of this last condenser are short-circuited by a relay and a single cell. When the adjustments are properly made, it is claimed that the receiver responds only to waves coming from its own syntonized or tuned transmitter. In this case, the length of the receiving aerial above the point of junction with the coherer circuit is one quarter the length of the wave. A variation of the above arrangements consists in making this lateral circuit equal in length to one half of a wave, and connecting the coherer to its center through a condenser to the earth. The outer end of this lateral circuit is also connected to the earth (see Fig. 24).*

Dr. Slaby claims that this arrangement is not affected by atmospheric electricity, and that the complete and direct earthing of the aerial and also in the second arrangement, of the receiver of the outer end of the lateral conductor, conduces to preserve the receiver immune from any electrical disturbances except those having a period to which it is tuned.

A method has also been arranged by him for receiving on the same aerial two messages from different transmitting stations, simultaneously. In this case, two lateral wires of different lengths are connected to the receiving aerial, and to the outer end of each of these is connected a coherer tube, the other end of which is earthed through a condenser. One of these lateral wires is made equal or nearly equal in length to the aerial and the other is made longer to fulfil the following condition.† If we call *H* the height of the receiving aerial above point of junction of the lateral wires, then the length of one lateral wire is made equal to *H*, and the height of the aerial is adjusted to be equal to one quarter of the wave-length of one incident wave. The other lateral wire may then be made of a length equal to one third of *H* and it will then respond to the first odd harmonic of that wave, of which the fundamental is in syntony with the vertical wire. By suitably choosing the relation between the wave lengths of the two transmitting stations, it is possible to receive in this manner two different

* See German Patent Specifications, Class 21a, No. 7,452 of 1900 and also No. 8,087 of 1901.

† See German Patent Specification, Class 21a, No. 7,498 of 1900, applied for November 9, 1900. The above-mentioned patent is subsequent in date to Mr. Marconi's experiments on the same subject.

messages at the same time on the same aerial. Subsequently to the date of the above-mentioned demonstration of multiplex wireless telegraphy by Mr. Marconi, an exhibition of a similar nature was given by Professor Slaby in a lecture given in Berlin on December 22, 1900.*

Both the above described syntonic systems of Mr. Marconi and Dr. Slaby are 'earthed' systems, but arrangements for syntonic telegraphy have been devised by Sir Oliver Lodge and Professor Braun, which are 'non-earthed.'

Sir Oliver Lodge and Dr. Muirhead have devised also syntonic systems. According to their last methods, the syntonic transmitting and receiving arrangements are as shown in Fig. 25.† On examining the

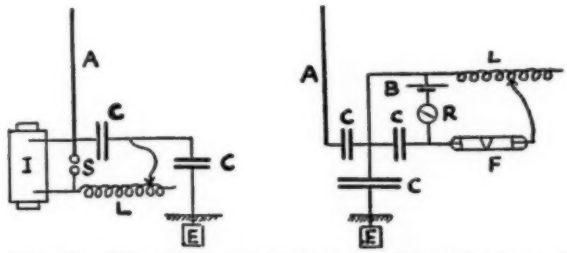


FIG. 25. LODGE-MUIRHEAD SYNTONIC RECEIVER. *I*, induction coil; *S*, spark gap; *A*, aerial; *C, C*, condensers; *E*, earth plate; *R*, relay; *L*, variable inductance; *F*, filings tube; *B*, battery.

diagrams, it will be seen that the secondary terminals of the induction coil are, as usual, connected to a pair of spark balls, and that these spark balls are connected by a condenser and by a variable inductance. One terminal of the condenser is earthed through another condenser of large capacity, and the remaining terminal of the first condenser is connected to an aerial. It should therefore be borne in mind in dealing with electrical oscillations that a condenser of sufficient capacity is practically a conductor, and an inductance coil of sufficient inductance is practically a non-conductor. Hence the insertion of a large capacity in the path of the aerial wire is no advantage whatever and makes no essential difference in the arrangement. In order to obtain any powerful radiation, the length of the aerial or sky wire, as they call it, must be so adjusted that its length is one quarter the wave length corresponding to the oscillation circuit, consisting of the condenser and variable inductance.

The receiving arrangement consists of a similar sky wire or aerial earthed through a condenser of large capacity and having in the portion above this last condenser another condenser of similar capacity. At the earthed side of this last condenser a connection is made to a resonant circuit, consisting of a variable inductance, and another con-

* See *Electrician*, January 18, 1900, Vol. XLVI., p. 475. Also reprint of a paper of Professor A. Slaby, 'Abgestimmte und mehrfache Funkentelegraphie.'

† See British Specification, No. 11,348 of 1901.

denser and a sensitive metallic filings tube of the Branly type; also a portion of this resonant circuit is shunted by another consisting of a battery and telegraphic relay, as shown in the diagram. The circuit, including the coherer, is tuned to its own aerial and also to that of the transmitting circuit, and under these circumstances trains of waves thrown off at the transmitting aerial will sympathetically affect the receiving aerial.

There is nothing in the arrangement which specially calls for notice. It is simply a variation of other known forms of syntonic transmitter and receiver, and possesses all the advantages and disadvantages attaching to such electrical syntonic methods.

Professor Braun's syntonic system, the receiver and transmitter of which have been described, is also in one form a non-earthed system. Innumerable other patentees have taken out patents for devices which are modifications in small degree of the above arrangements.

It may be well to note at this point the disadvantages that are possessed by any form of coherer as a telegraphic kumascope in connection with proposed arrangements for the isolation of Hertzian wave stations. All the detectors of the coherer type really depend for their actuation upon electromotive force; that is to say, upon the application to the terminals of the detector of a certain electromotive force. Although there may be no sharp and defined critical electromotive force, yet, nevertheless, as a matter of fact, if the electromotive force applied exceeds a certain value, then the detector passes suddenly from one state of conductivity to another. It may be of great conductivity, as in the case of the Branly coherer, or of lesser conductivity, as in the case of the so-called anticoherers, of which the Schäfer kumascope may be taken as a type. Accordingly, when these instruments are subjected to a train of waves, each individual group of which is damped, their operation is largely governed by the fact that if the first wave or oscillation set up in the receiving circuit is powerful enough to break down the coherer, then the receiving mechanism acts, no matter whether the first impulse is followed by others or not.

In comparison with so-called coherers, those depending upon the changes in the magnetization of iron by electrical oscillations certainly have an advantage, because this is a process which requires the application of alternating electric currents decreasing in strength for a certain time; and it is found therefore that the magnetic receivers do not require to be associated with such a stiff or irresponsive resonant circuit to confine their indications to oscillations or waves of one definite period, and that they lend themselves much more perfectly to the work of 'tuning' or syntonizing stations than do those kumascopes depending upon the contact or coherer principle.

We may then glance at the alternative solutions of the problem offered by other investigators. M. Blondel has proposed to effect the

syntonization of two stations, not by syntonizing the receiver for the exceedingly high frequency oscillations of the individual electric waves, but to syntonize it for the much lower frequency, corresponding to that of the intervals between the groups of waves. Thus, for instance, if an ordinary simple transmitting aerial is set up, the production of sparks between the spark balls results in the emission of short trains of waves, each of which may consist of half a dozen or more individual waves, the time of production of the whole group being very small compared with the interval between the groups. M. Blondel proposes, however, to syntonize the receiver, not for the high frequency period of the waves themselves, which may be reckoned in millions per second, but for the low frequency period between the groups of waves, which is reckoned in hundreds per second. Thus, for instance, if sparks are made at the rate of fifty or a hundred per second, they can be made to actuate the telephone receiver and so produce in the telephone a sound corresponding to a frequency of 50 or 100. In other words, to make a low musical note or hum. This continuous sound can be cut up, by means of a key placed in the primary circuit of the transmitting arrangement, into long or short periods, and hence the letters of the alphabet signal.

M. Blondel's arrangements comprise a Mercadier's monotone telephone and either a coherer or a particular form of vacuum tube as a kumascope. On August 16, 1898, M. Blondel deposited with the Academy of Sciences in Paris a sealed envelope containing a description of his improvements in syntonic wireless telegraphy, which was opened on May 19, 1900.* The arrangement of the receiving apparatus was as follows: A single battery cell keeps a condenser charged until the kumascope is rendered conductive by the oscillations coming down the aerial; and under these circumstances the condenser discharges through the telephone and causes a tick to be heard in it. If the trains of waves are at the rate of 50 or 100 per second, these small sounds run together into a musical note, and this continuous hum can be cut up into long and short spaces, in accordance with the Morse alphabet signals. The telephone must not be an ordinary telephone, capable of being influenced by any frequency, but be one which responds only to a particular note, and under these conditions the receiving arrangement is receptive only when the trains of waves arrive at certain regular predetermined intervals, corresponding with the tone to which the telephone is sensitive.

* See *Comptes Rendus*, May 21, 1900; *Rapports du Congrès International d'Electricité*, Paris, 1900, p. 341.

THE BRIGHT SIDE OF RUSSIAN IMMIGRATION.

By Dr. ALLAN McLAUGHLIN,
U. S. PUBLIC HEALTH AND MARINE-HOSPITAL SERVICE.

A LARGE proportion of the immigrants giving Russia as their birthplace crowd into the tenements of the east side of New York City and furnish operatives for the sweat shops and material for all the charitable organizations in the city.

These immigrants are so prominently in the public eye that we hear a great deal about the alarming and deplorable increase in Russian immigration. The casual newspaper reader does not find out that from Russia we receive five distinct racial elements and that only one of the five races tends to congregate in New York City, the other four being distributed among the mines, farms and factories in nearly every state in the union. So much is published about the sweat shop and the tenement that the reader is apt to lose sight of the fact that we receive a great many very desirable immigrants from Russia.

Fifty years ago the question of what constituted a desirable immigrant was a vexed one and many claimed that no such thing as a desirable immigrant existed. Time has modified the views of the extremist and proved that an immigrant with a good physique, willing to work and obey the law, has a definite economic value. This is especially true if he is between the ages of fifteen and forty-five years and is an unskilled laborer. Three races stand out preeminently among the races of Russia as furnishing a very large proportion of desirable immigrants. They are the Russian-German, Lithuanian and Finn.

The following table shows the immigration from Russia during 1902, arranged by races, and shows the relative standing of these races in some of the essential factors of desirability:

Race.	Number Landed.	Per Cent. Between Ages of 14 and 45.	Per Cent. Unskilled Laborers.	Per Cent. Remaining in New York.
Russian-German	8,542	75	90	5
Finn	13,854	90	86	12
Lithuanian	9,975	91	86	15
Pole	33,859	88	82	20
Hebrew	37,846	67	13	68

Russian-Germans.

The term 'Russian-German' sounds paradoxical, but it in reality describes the racial status of this people more accurately than any other designation.

Germans have been landlords in the Russian Baltic provinces since the days of the old German order of crusaders, The Sword Brothers

of Livonia. German artisans were imported and enjoyed the favor of the Great Peter, and German farmers took advantage of the breaking up of the large Polish estates after the insurrection of 1863 to establish themselves upon much of the best farming land in Poland. But none of these different divisions of the German race in Russia concerns us in our consideration of the Russian-German immigrant. He has a history entirely his own and has no more connection with other isolated colonies of Germans in Russia than he has with the Russian, from whom he holds himself religiously aloof.

Anne, daughter of Peter the Great, married the Duke of Holstein Gottorp, a German prince, and their son, who was crowned Peter III., was thus half German. Peter III. married a German princess, Sophia, of Anhalt Zerbst, who later deposed him and became sole ruler of the country, taking the name of Catherine II. The Ukraine, or country north of the Black Sea, which was the most fertile part of Russia, had never been consistently cultivated. This magnificent 'black mold belt,' one of the finest wheat-raising regions in the world, could only be kept from the Tartar hordes by the employment of the Cossacks as a protection. The Cossacks effectually prevented further Tartar raids, but were not farmers; and to develop this fine country Catherine offered special inducements to German settlers.

These inducements included the use of their own schools and the practise of their own religion, exemption from military service and some other special privileges. Many Germans took advantage of their countrywoman's liberal offer. As a result there are to-day in southern Russia in the governments immediately north of the Black Sea thousands of Germans who speak only German, who are in religion Lutherans and who are by far the most prosperous agricultural class in Russia.

The present Tsar has withdrawn the privileges granted by the Empress Catherine, has sought to replace the German schools by Russian, and the Lutheran religion by the Greek orthodox church; but he has only succeeded in exiling from Russia thousands of these German farmers, who come as immigrants to America with the proceeds of their Russian farms in their pockets and the courage of the pioneer in their hearts.

The Finns.

The Finns belong to the Ugro-Finnic or Uralo-Altaic stock and are akin to the Magyar and Laplander. About a dozen different tribes of this Ugro-Finnic stock are recognized; they are scattered over northern and central Russia and Siberia.

It must be remembered that the classification of Finnic peoples is made from a philological view-point, without regard to the influence great or slight which surrounding races may have exerted on the racial type. Otherwise it would often be hard to believe that the Finnish immigrant was of the same race as the Lapp, Magyar or Volga Finn.

The Finns are said to have lived on the Volga in the seventh century and to have been driven north in the eighth century to their present home. They were conquered and christianized in the twelfth century by the Swedes, who occupied and ruled the country for more than five hundred years. In the wars between Sweden and Russia, Finland was often the battleground, and finally by treaty in 1809 Sweden ceded the grand duchy of Finland to Russia.

The Finnish constitution of 1772 afforded ample protection to the liberties of the people. It insured practical autonomy in internal affairs and provided that the Finnish army could not be required to serve outside of Finland. Alexander I. guaranteed to Finland the preservation of its laws, constitution and religion, and this pledge has been renewed by each succeeding ruler, including the present Tsar, Nicholas II., who however has broken his pledge. The condition of the Finns under their own constitution has been much better than that of any other subjects of the Tsar. Serfdom never existed in their country and five ninths of the land was owned by peasants. The policy of Russianization pursued by Tsar Nicholas II. since 1898 has practically set aside the constitution and reduced the grand duchy of Finland to the status of an ordinary Russian province.

Since 1863 Russia has attempted to eliminate Swedish influence by fostering the growth of the native language and literature. Now, however, the Finnish language is placed under the ban and the removal of high officials of Finland's educational system and the substitution of Russians in their places at Helsingfors and other educational centers may be considered an indication of the coming suppression of the Finnish language in the schools.

The majority of our Finnish immigrants come from near the coast, and in this locality the Swedish influence upon the people is shown most markedly by the frequent great variation from the recognized Finnish type. It is difficult in some cases to differentiate them from the Swedes and it is rare to find among these immigrants the broad head, flat features, yellow skin, obliquely set eyes, or other characteristics of the Ugro-Finnic type. They are tall and well proportioned, sometimes with fair complexions, sometimes with a queer combination of the characteristics of Finn and Swede. Eighty per cent. of the Finns are engaged in agricultural pursuits. They are honest, industrious and energetic; and it is a very rare occurrence to find an illiterate Finn.

Lithuanians.

The Lithuanian people, according to their traditions and the researches of some eminent ethnologists, were probably the first of the Aryan race to settle in Europe. Their first European home seems to have been in the valley of the Danube in the country now known as Bulgaria. The valley of the Danube was the natural highway of in-

vasion used by the fierce Asiatic tribes in their incursions westward. Wars of the Romans against the Dacians and successive invasions of Goth and Hun forced the Lithuanians to seek a new home out of the path of invasion and conflict.

They migrated northward, probably during the third and fourth centuries, and following the valley of the Vistula spread out over territory extending from the mouth of the Vistula to the shore of Lake Peipus and southward to the great marshes of Pinsk. Their early history is necessarily hazy, depending upon tradition and scientific deduction. From the tenth century their history is fairly clear and about this time we find the Lithuanian nation divided into three main branches, viz., Borussians, Letts and Samoghitians.

The Borussians, who occupied territory in the vicinity of Königsberg, East Prussia, soon fell under German influence and lost their political existence, leaving only their name corrupted into Prussia.

The Letts occupied the country now known as the Baltic provinces of Russia. They mixed with and dominated the Livs and Esths (Finnish tribes occupying Livonia and Esthonia) and with these tribes became subject to a German religious order with a military organization known as the Sword Brothers of Livonia.

The Samoghitians, or Lithuanians proper, occupied territory south of the Baltic provinces. There they formed an independent state and resisted successfully all efforts of German crusader, Slav and Tartar to subjugate them. In the fourteenth century the king of Lithuania ruled the country occupied to-day by Poles, Lithuanians and white Russians. In 1386 Yagello, king of Lithuania, married Yadviga, queen of Poland, was baptized into the Latin church and crowned king of Poland. Lithuania during this reign reached the zenith of her power and extended her dominions to the River Moskwa on the east and to the Black Sea on the south. The union with Poland was nominal at this time, but a real union took place in 1569 when, by the treaty of Lublin, Lithuania ceased to exist politically. From that time to the present the history of Lithuania has been that of Poland.

The absorption of the Livs and other Finnish elements by the Letts has made that branch of the Lithuanian race more or less of a mixed type. The Borussians, or Lithuanians of Prussia, rarely emigrate.

The uninviting nature of the country occupied by the Samoghitians or Lithuanians proper and its inaccessibility, owing to vast tracts of marsh and forest land, helped to preserve the racial characteristics, and the Samoghitian is to-day a distinct type bearing no resemblance to surrounding races. A typical Lithuanian has the features of a Greek and the complexion of a Norseman. They are tall and splendidly proportioned, towering over their Slavic neighbors. The stature and fine physique of the Russian Imperial Guard are due to the fact that it is recruited almost entirely in the Lithuanian prov-

inces. Their fair complexion, long face and clear-cut features make them readily distinguishable from the Slavs, whose squat figures and wide faces are accentuated by the contrast. Their language is very old and primitive and is said to resemble Sanskrit so closely that Lithuanian peasants can understand Sanskrit phrases. Their written literature is very scanty, but their unwritten popular folk-lore is rich in idyllic and lyric songs and poetry of a pastoral variety and melancholy tone. They are very proud of their ancestry and resent being considered Slavs. They claim with pride that most of Poland's great men, Kosciusko, Chodkiewicz, Sienkewicz and others were Lithuanians. Their occupation is agriculture. The land owners have always been Polish or German and business is carried on by Jews and Germans.

Few words are necessary to convince one of the desirability of the Russian-German. He has the industry, thrift and sterling honesty that have made his brother Germans from the Fatherland welcome and successful in this country. He is a picturesque figure clad in sheepskin garments, which add to his appearance of splendid physique. He represents the best type of the agricultural immigrant who comes here to make a home in the far west with the necessary money in his pocket to buy land and give him his start.

The Finns are also an agricultural or pastoral people, and if they possess less money than the Russian-Germans their sturdy physique and willingness to work make their success certain in this country. They work on farms in the northern central states and have been valuable as laborers in the development of the mines of northern Michigan and Wisconsin. The ability of the Finns to withstand the rigors of a northern climate, and their well-known thrift and industry, have suggested the possibility of their being valuable in the agricultural and mining development of Alaska. A colony of Finns in Canada has been very successful in wheat raising on the shores of Great Slave Lake, a latitude once considered scarcely habitable for white men.

The Lithuanians are also agricultural or pastoral in occupation, but in this country are largely employed as laborers in the mines of Pennsylvania and other mining states. Their rugged physique fits them for this rough work, and so long as the industrial demand for unskilled labor keeps up so long will the Lithuanian be valuable as the best type of this class of immigrants.

A careful study of the statistics of immigration and of economic and social conditions in this country will convince any one that there is little to fear from such races as the Russian-German, Finn and Lithuanian properly inspected under our present laws; and that future legislation aiming to cut down the number of undesirable immigrants must be directed toward debarring the competitive and parasitic classes which now crowd our great cities.

THE INFLUENCE OF BRAIN-POWER ON HISTORY.

By Sir NORMAN LOCKYER,
ROYAL COLLEGE OF SCIENCE.

SOME years ago, in discussing the relations of scientific instruction to our industries, Huxley pointed out that we were in presence of a new 'struggle for existence,' a struggle which, once commenced must go on until only the fittest survives.

It is a struggle between organized species—nations—not between individuals or any class of individuals. It is, moreover, a struggle in which science and brains take the place of swords and sinews, on which depended the result of those conflicts which, up to the present, have determined the history and fate of nations. The school, the university, the laboratory and the workshop are the battlefields of this new warfare.

But it is evident that if this, or anything like it, be true, our industries can not be involved alone; the scientific spirit, brain-power, must not be limited to the workshop if other nations utilize it in all branches of their administration and executive.

It is a question of an important change of front. It is a question of finding a new basis of stability for the Empire in face of new conditions. I am certain that those familiar with the present states of things will acknowledge that the Prince of Wales's call, 'Wake up,' applies quite as much to the members of the government as it does to the leaders of industry.

What is wanted is a complete organization of the resources of the nation, so as to enable it best to face all the new problems which the progress of science, combined with the ebb and flow of population and other factors in international competition, are ever bringing before us. Every minister, every public department, is involved, and this being so, it is the duty of the whole nation—king, lords and commons—to do what is necessary to place our scientific institutions on a proper footing in order to enable us to 'face the music' whatever the future may bring. The idea that science is useful only to our industries comes from want of thought. If any one is under the impression that Britain is only suffering at present from the want of the scientific spirit among our industrial classes, and that those employed in the state service possess adequate brain-power and grip of the conditions

* From the address of the president of the British Association for the Advancement of Science, Southport, 1903.

of the modern world into which science so largely enters, let him read the report of the Royal Commission on the War in South Africa. There he will see how the whole 'system' employed was, in Sir Henry Brackenbury's words applied to a part of it, *'unsuited to the requirements of an Army which is maintained to enable us to make war.'* Let him read also, in the address of the president of the Society of Chemical Industry, what drastic steps had to be taken by Chambers of Commerce and 'a quarter of a million of working men' to get the Patent Law Amendment Act into proper shape, in spite of all the advisers and officials of the Board of Trade. Very few people realize the immense number of scientific problems the solution of which is required for the state service. The nation itself is a gigantic workshop, and the more our rulers and legislators, administrators and executive officers possess the scientific spirit, the more the rule of thumb is replaced in the state service by scientific methods, the more able shall we be, thus armed at all points, to compete successfully with other countries along all lines of national as well as of commercial activity.

It is obvious that the power of a nation for war, in men and arms and ships, is one thing; its power in the peace struggles to which I have referred is another; in the latter, the source and standard of national efficiency are entirely changed. To meet war conditions, there must be equality or superiority in battleships and army corps. To meet the new peace conditions there must be equality or superiority in universities, scientific organizations and everything which conduces to greater brain-power.

The present condition of the nation, so far as its industries are concerned, is as well known, not only to the Prime Minister, but to other political leaders in and out of the Cabinet, as it is to you and to me. Let me refer to two speeches delivered by Lord Rosebery and Mr. Chamberlain on two successive days in January, 1901:

Lord Rosebery spoke as follows:

. . . The war I regard with apprehension is the war of trade which is unmistakably upon us. . . . When I look round me I cannot blind my eyes to the fact that so far as we can predict anything of the twentieth century on which we have now entered, it is that it will be one of acutest international conflict in point of trade. We were the first nation of the modern world to discover that trade was an absolute necessity. For that we were nicknamed a nation of shopkeepers; but now every nation wishes to be a nation of shopkeepers, too, and I am bound to say that when we look at the character of some of these nations, and when we look at the intelligence of their preparations, we may well feel that it behooves us not to fear, but to gird up our loins in preparation for what is before us.

Mr. Chamberlain's views were stated in the following words:

I do not think it is necessary for me to say anything as to the urgency and necessity of scientific training. . . . It is not too much to say that the

existence of this country, as the great commercial nation, depends upon it. . . . It depends very much upon what we are doing now, at the beginning of the twentieth century, whether at its end we shall continue to maintain our supremacy or even equality with our great commercial and manufacturing rivals.

All this refers to our industries. We are not suffering because trade no longer follows the flag as in the old days, but because trade follows the brains, and our manufacturers are too apt to be careless in securing them. In one chemical establishment in Germany, 400 doctors of science, the best the universities there can turn out, have been employed at different times in late years. In the United States the most successful students in the higher teaching centers are snapped up the moment they have finished their course of training, and put into charge of large concerns, so that the idea has got abroad that youth is the password of success in American industry. It has been forgotten that the latest product of the highest scientific education must necessarily be young, and that it is the training and not the age which determines his employment. In Britain, on the other hand, apprentices who can pay high premiums are too often preferred to those who are well educated, and the old rule-of-thumb processes are preferred to new developments—a conservatism too often depending upon the master's own want of knowledge.

I should not be doing my duty if I did not point out that the defeat of our industries one after another, concerning which both Lord Rosebery and Mr. Chamberlain express their anxiety, is by no means the only thing we have to consider. The matter is not one which concerns our industrial classes only, for knowledge must be pursued for its own sake, and since the full life of a nation with a constantly increasing complexity, not only of industrial, but of high national aims, depends upon the universal presence of the scientific spirit—in other words, brain power—our whole national life is involved.

The present awakening in relation to the nation's real needs is largely due to the warnings of men of science. But Mr. Balfour's terrible Manchester picture of our present educational condition * shows that the warning which has been going on now for more than fifty years has not been forcible enough; but if my contention that other reorganizations besides that of our education are needed is well founded, and if men of science are to act the part of good citizens in taking their share in endeavoring to bring about a better state of things, the question arises, has the neglect of their warnings so far been due to the way in which these have been given?

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* "The existing educational system of this country is chaotic, is ineffectual, is utterly behind the age, makes us the laughing-stock of every advanced nation in Europe and America, puts us behind, not only our American cousins, but the German and the Frenchman and the Italian."—*Times*, October 15, 1902.

Lord Rosebery, in the address to a Chamber of Commerce from which I have already quoted, expressed his opinion that such bodies do not exercise so much influence as might be expected of them. But if commercial men do not use all the power their organization provides, do they not by having built up such an organization put us students of science to shame, who are still the most disorganized members of the community?

Here, in my opinion, we have the real reason why the scientific needs of the nation fail to command the attention either of the public or of successive governments. At present, appeals on this or on that behalf are the appeals of individuals; science has no collective voice on the larger national questions; there is no organized body which formulates her demands.

During many years it has been part of my duty to consider such matters, and I have been driven to the conclusion that our great crying need is to bring about an organization of men of science and all interested in science, similar to those which prove so effective in other branches of human activity. For the last few years I have dreamt of a Chamber, Guild, League, call it what you will, with a wide and large membership, which should give us what, in my opinion, is so urgently needed. Quite recently I sketched out such an organization, but what was my astonishment to find that I had been forestalled, and by the founders of the British Association!

At the commencement of this address I pointed out that one of the objects of the Association, as stated by its founders, was 'to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress.'

Every one connected with the British Association from its beginning may be congratulated upon the magnificent way in which the other objects of the Association have been carried out, but as one familiar with the Association for the last forty years, I can not but think that the object to which I have specially referred has been too much overshadowed by the work done in connection with the others.

A careful study of the early history of the association leads me to the belief that the function I am now dwelling on was strongly in the minds of the founders; but be this as it may, let me point out how admirably the organization is framed to enable men of science to influence public opinion and so to bring pressure to bear upon governments which follow public opinion. (1) Unlike all the other chief metropolitan societies, its outlook is not limited to any branch or branches of science. (2) We have a wide and numerous fellowship, including both the leaders and the lovers of science, in which all branches of science are and always have been included with the utmost catholicity—a condition which renders strong committees possible on

any subject. (3) An annual meeting at a time when people can pay attention to the deliberations, and when the newspapers can print reports. (4) The possibility of beating up recruits and establishing local committees in different localities, even in the King's dominions beyond the seas, since the place of meeting changes from year to year, and is not limited to these islands.

We not only, then, have a scientific parliament competent to deal with all matters, including those of national importance, relating to science, but machinery for influencing all new councils and committees dealing with local matters, the functions of which are daily becoming more important.

The machinery might consist of our corresponding societies. We already have affiliated to us seventy societies with a membership of 25,000; were this number increased so as to include every scientific society in the Empire, metropolitan and provincial, we might eventually hope for a membership of half a million.

I am glad to know that the Council is fully alive to the importance of giving impetus to the work of the corresponding societies. During this year a committee was appointed to deal with the question; and later still, after this committee had reported, a conference was held between this committee and the corresponding societies committee to consider the suggestions made, some of which will be gathered from the following extract:

> In view of the increasing importance of science to the nation at large, your committee desire to call the attention of the council to the fact that in the corresponding societies the British Association has gathered in the various centers represented by these societies practically all the scientific activity of the provinces. The number of members and associates at present on the list of the corresponding societies approaches 25,000, and no organization is in existence anywhere in the country better adapted than the British Association for stimulating, encouraging and coordinating all the work being carried on by the seventy societies at present enrolled. Your committee are of opinion that further encouragement should be given to these societies and their individual working members by every means within the power of the association; and with the object of keeping the corresponding societies in more permanent touch with the association they suggest that an official invitation on behalf of the council be addressed to the societies through the corresponding societies committee asking them to appoint standing British Association sub-committees, to be elected by themselves with the object of dealing with all those subjects of investigation common to their societies and to the British Association committees, and to look after the general interests of science and scientific education throughout the provinces and provincial centers. . . .
>
> Your committee desire to lay special emphasis on the necessity for the extension of the scientific activity of the corresponding societies and the expert knowledge of many of their members in the direction of scientific education. They are of opinion that immense benefit would accrue to the country if the corresponding societies would keep this requirement especially in view with the object of securing adequate representation for scientific education on the edu-

cation committees now being appointed under the new Act. The educational section of the association having been but recently added, the corresponding societies have as yet not had much opportunity for taking part in this branch of the association's work; and in view of the reorganization in education now going on all over the country your committee are of opinion that no more opportune time is likely to occur for the influence of scientific organizations to make itself felt as a real factor in national education. . . .

I believe that if these suggestions or anything like them—for some better way may be found on inquiry—are accepted, great good of science throughout the Empire will come. Rest assured that sooner or later such a guild will be formed because it is needed. It is for you to say whether it shall be, or form part of, the British Association. We in this Empire certainly need to organize science as much as in Germany they find the need to organize a navy. The German Navy League, which has branches even in our Colonies, already has a membership of 630,000, and its income is nearly 20,000*l.* a year. A British Science League of 500,000 with a sixpenny subscription would give us 12,000*l,* a year, quite enough to begin with.

I for one believe that the British Association would be a vast gainer by such an expansion of one of its existing functions. Increased authority and prestige would follow its increased utility. The meetings would possess a new interest; there would be new subjects for reports; missionary work less needed than formerly would be replaced by efforts much more suited to the real wants of the time. This magnificent, strong and complicated organization would become a living force, working throughout the year, instead of practically lying idle, useless and rusting for 51 weeks out of the 52 so far as its close association with its members is concerned.

If this suggestion in any way commends itself to you, then when you begin your work in your sections or general committee see to it that a body is appointed to inquire how the thing can be done. Remember that the British Association will be as much weakened by the creation of a new body to do the work I have shown to have been in the minds of its founders as I believe it will be strengthened by becoming completely effective in every one of the directions they indicated, and for which effectiveness we their successors are indeed responsible. The time is appropriate for such a reinforcement of one of the wings of our organization, for we have recently included education among our sections.

There is another matter I should like to see referred to the committee I have spoken of, if it please you to appoint it. The British Association, which as I have already pointed out is now the chief body in the Empire which deals with the totality of science, is, I believe, the only organization of any consequence which is without a charter, and which has not His Majesty the King as patron.

I suppose it is my duty after I have suggested the need of organization to tell you my personal opinion as to the matters where we suffer most in consequence of our lack of organization at the present time.

Our position as a nation, our success as merchants, are in peril chiefly—dealing with preventable causes—because of our lack of completely efficient universities, and our neglect of research: This research has a double end. A professor who is not learning can not teach properly or arouse enthusiasm in his students; while a student of anything who is unfamiliar with research methods, and without that training which research brings, will not be in the best position to apply his knowledge in after life. From neglect of research come imperfect education and a small output of new applications and new knowledge to reinvigorate our industries. From imperfect education come the unconcern touching scientific matters, and the too frequent absence of the scientific spirit, in the nation generally from the court to the parish council.

I propose to deal as briefly as I can with each of these points.

I have shown that so far as our industries are concerned, the cause of our failure has been run to earth; it is fully recognized that it arises from the insufficiency of our universities both in numbers and efficiency, so that not only our captains of industry, but those employed on the nation's work generally, do not secure a training similar to that afforded by other nations. No additional endowment of primary, secondary or technical instruction will mend matters. This is not merely the opinion of men of science; our great towns know it, our ministers know it.

It is sufficient for me to quote Mr. Chamberlain:

> It is not every one who can, by any possibility, go forward into the higher spheres of education; but it is from those who do that we have to look for the men who, in the future, will carry high the flag of this country in commercial, scientific and economic competition with other nations. At the present moment, I believe there is nothing more important than to supply the deficiencies which separate us from those with whom we are in the closest competition. In Germany, in America, in our own colony of Canada and in Australia, the higher education of the people has more support from the government, is carried further, than it is here in the old country; and the result is that in every profession, in every industry, you find the places taken by men and by women who have had a university education. And I would like to see the time in this country when no man should have a chance for any occupation of the better kind, either in our factories, our workshops or our counting-houses, who could not show proof that, in the course of his university career, he had deserved the position that was offered to him. What is it that makes a country? Of course you may say, and you would be quite right, 'The general qualities of the people, their resolution, their intelligence, their pertinacity, and many other good qualities.' Yes; but that is not all, and it is not the main creative feature of a great nation. The greatness of a nation is made by its greatest men. It is those we want to educate. It is to those who are able to go, it may be, from

the very lowest steps in the ladder, to men who are able to devote their time to higher education, that we have to look to continue the position which we now occupy as, at all events, one of the greatest nations on the face of the earth. And, feeling as I do on these subjects, you will not be surprised if I say that I think the time is coming when governments will give more attention to this matter, and perhaps find a little more money to forward its interests (*Times*, November 6, 1902).

Our conception of a university has changed. University education is no longer regarded as a luxury of the rich which concerns only those who can afford to pay heavily for it. The Prime Minister in a recent speech, while properly pointing out that the collective effect of our public and secondary schools upon British character can not be overrated, frankly acknowledged that the boys of seventeen or eighteen who have to be educated in them 'do not care a farthing about the world they live in except in so far as it concerns the cricket-field or the football-field or the river.' On this ground they are not to be taught science, and hence, when they proceed to the university, their curriculum is limited to subjects which were better taught before the modern world existed, or even Galileo was born. But the science which these young gentlemen neglect, with the full approval of their teachers, on their way through the school and the university to politics, the civil service or the management of commercial concerns, is now one of the great necessities of a nation, and our universities must become as much the insurers of the future progress as battleships are the insurers of the present power of states. In other words, university competition between states is now as potent as competition in building battleships, and it is on this ground that our university conditions become of the highest national concern and, therefore, have to be referred to here, and all the more because our industries are not alone in question.

Chief among the causes which have brought us to the terrible condition of inferiority as compared with other nations in which we find ourselves are our carelessness in the matter of education and our false notions of the limitations of state functions in relation to the conditions of modern civilization.

Time was when the navy was largely a matter of private and local effort. William the Conqueror gave privileges to the Cinque Ports on the condition that they furnished fifty-two ships when wanted. In the time of Edward III., of 730 sail engaged in the siege of Calais, 705 were 'people's ships.' All this has passed away; for our first line of defense we no longer depend on private and local effort.

Time was when not a penny was spent by the state on elementary education. Again, we no longer depend upon private and local effort. The navy and primary education are now recognized as properly calling upon the public for the necessary financial support. But when we pass from primary to university education, instead of state endow-

ment we find state neglect; we are in a region where it is nobody's business to see that anything is done.

We in Great Britain have thirteen universities competing with 134 state and privately endowed in the United States and 22 state endowed in Germany. I leave other countries out of consideration for lack of time, and I omit all reference to higher institutions for technical training, of which Germany alone possesses nine of university rank, because they are less important; they instruct rather than educate, and our want is education. The German State gives to one university more than the British Government allows to all the universities and university colleges in England, Ireland, Scotland and Wales put together. These are the conditions which regulate the production of brain-power in the United States, Germany and Britain respectively, and the excuse of the government is that this is a matter for private effort. Do not our Ministers of State know that other civilized countries grant efficient state aid, and further, that private effort has provided in Great Britain less than 10 per cent. of the sum thus furnished in the United States in addition to state aid? Are they content that we should go under in the great struggle of the modern world because the ministers of other states are wiser, and because the individual citizens of another country are more generous, than our own?

If we grant that there was some excuse for the state's neglect so long as the higher teaching dealt only with words, and books alone had to be provided (for the streets of London and Paris have been used as class rooms at a pinch), it must not be forgotten that during the last hundred years not only has knowledge been enormously increased, but things have replaced words, and fully equipped laboratories must take the place of books and class rooms if university training worthy of the name is to be provided. There is much more difference in size and kind between an old and a new university than there is between the old caravel and a modern battleship, and the endowments must follow suit.

What are the facts relating to private endowment in this country? In spite of the munificence displayed by a small number of individuals in some localities, the truth must be spoken. In depending in our country upon this form of endowment, we are trusting to a broken reed. If we take the twelve English university colleges, the forerunners of universities unless we are to perish from lack of knowledge, we find that private effort during sixty years has found less than 4,000,000*l.*, that is, 2,000,000*l.* for buildings and 40,000*l.* a year income. This gives us an average of 166,000*l.* for buildings and 3,300*l.* for yearly income.

What is the scale of private effort we have to compete with in regard to the American universities?

In the United States, during the last few years, universities and

colleges have received more than 40,000,000*l.* from this source alone; private effort supplied nearly 7,000,000*l.* in the years 1898–1900.

Next consider the amount of state aid to universities afforded in Germany. The buildings of the new University of Strassburg have already cost nearly a million; that is, about as much as has yet been found by private effort for buildings in Manchester, Liverpool, Birmingham, Bristol, Newcastle and Sheffield. The government annual endowment of the same German university is more than 49,000*l.*

This is what private endowment does for us in England, against state endowment in Germany.

But the state does really concede the principle; its present contribution to our universities and colleges amounts to 155,600*l.* a year; no capital sum, however, is taken for buildings. The state endowment of the University of Berlin in 1891–2 amounted to 168,777*l.*

When, then, we consider the large endowments of university education both in the United States and Germany, it is obvious that state aid only can make any valid competition possible with either. The more we study the facts, the more statistics are gone into, the more do we find that we, to a large extent, lack both of the sources of endowment upon one or other or both of which other nations depend. We are between two stools, and the prospect is hopeless without some drastic changes. And first among these, if we intend to get out of the present slough of despond, must be the giving up of the idea of relying upon private effort.

That we lose most where the state does least is known to Mr. Chamberlain, for in his speech, to which I have referred, on the University of Birmingham, he said: "As the importance of the aim we are pursuing becomes more and more impressed upon the minds of the people, we may find that we shall be more generously treated by the state."

Later still, on the occasion of a visit to University College School, Mr. Chamberlain spoke as follows:

"When we are spending, as we are, many millions—I think it is 13,000,000*l.*—a year on primary education, it certainly seems as if we might add a little more, even a few tens of thousands, to what we give to university and secondary education" (*Times*, November 6, 1902).

To compete on equal grounds with other nations we must have more universities. But this is not all—we want a far better endowment of all the existing ones, not forgetting better opportunities for research on the part of both professors and students. Another crying need is that of more professors and better pay. Another is the reduction of fees; they should be reduced to the level in those countries which are competing with us, to say, one fifth of their present rates, so as

to enable more students in the secondary and technical schools to complete their education.

In all these ways, facilities would be afforded for providing the highest instruction to a much greater number of students. At present there are almost as many *professors and instructors* in the universities and colleges of the United States as there are *day students* in the universities and colleges of the United Kingdom.

Men of science, our leaders of industry, and the chiefs of our political parties all agree that our present want of higher education—in other words, properly equipped universities—is heavily handicapping us in the present race for commercial supremacy, because it provides a relatively inferior brain-power which is leading to a relatively reduced national income.

The facts show that in this country we can not depend upon private effort to put matters right. How about local effort?

Any one who studies the statistics of modern municipalities will see that it is impossible for them to raise rates for the building and up-keep of universities.

The buildings of the most modern university in Germany have cost a million. For up-keep the yearly sums found, chiefly by the state, for German universities of different grades, taking the incomes of seven out of the twenty-two universities as examples are:

		£
1st Class	Berlin	130,000
2nd Class	Bonn, Göttingen	56,000
3rd Class	Königsberg, Strassburg	48,000
4th Class	Heidelberg, Marburg	37,000

Thus if Leeds, which is to have a university, is content with the 4th class German standard, a rate must be levied of 7*d.* in the pound for yearly expenses, independent of all buildings. But the facts are that our towns are already at the breaking strain. During the last fifty years, in spite of enormous increases in ratable values, the rates have gone up from about 2*s.* to about 7*s.* in the pound for real *local* purposes. But no university can be merely a local institution.

What, then, is to be done? Fortunately, we have a precedent admirably in point, the consideration of which may help us to answer this question.

I have pointed out that in old days our Navy was chiefly provided by local and private effort. Fortunately for us, those days have passed away; but some twenty years ago, in spite of a large expenditure, it began to be felt by those who knew that in consequence of the increase

of foreign navies, our sea-power was threatened, as now, in consequence of the increase of foreign universities, our brain-power is threatened.

The nation slowly woke up to find that its enormous commerce was no longer insured at sea, that in relation to foreign navies our own had been suffered to dwindle to such an extent that it was no longer capable of doing the duty which the nation expected of it even in time of peace. At first, this revelation was received with a shrug of incredulity, and the peace-at-any-price party denied that anything was needed; but a great teacher arose;* as the facts were inquired into the suspicion changed into an alarm; men of all parties saw that something must be done. Later, the nation was thoroughly aroused, and with universal agreement the principle was laid down that, cost what it might to enforce our sea-power, our Navy must be made and maintained of a strength greater than those of any two possibly contending powers. After establishing this principle, the next thing to do was to give effect to it. What did the nation do after full discussion and inquiry? A bill was brought in in 1888, and a sum of 21,500,000*l.* was voted in order, during the next five years, to inaugurate a large ship-building program, so that Britain and Britain's commerce might be guarded on the high seas in any event.

Since then we have spent 120,000,000*l.* on new ships, and this year we spend still more millions on still more new ships. If these prove insufficient to safeguard our sea-power, there is no doubt that the nation will increase them, and I have not heard that anybody has suggested an appeal to private effort.

How, then, do we stand with regard to universities, recognizing them as the chief producers of brain-power and therefore the equivalents of battleships in relation to sea-power? Do their numbers come up to the standard established by the Admiralty principle to which I have referred? Let us attempt to get a rough-and-ready estimate of our educational position by counting universities as the Admiralty counts battleships. I say rough and ready because we have other helps to greater brain-power to consider besides universities, as the Admiralty has other ships to consider besides ironclads.

In the first place, let us inquire if they are equal in number to those of any two nations commercially competing with us.

In the United Kingdom, we had until quite recently thirteen. Of these, one is only three years old as a teaching university and another is still merely an examining board.

* Captain Mahan, of the U. S. Navy, whose book, 'On the Influence of Sea-power on History,' has suggested the title of my address.

† These are Oxford, Cambridge, Durham, Victoria, Wales, Birmingham, London, St. Andrews, Glasgow, Aberdeen, Edinburgh, Dublin and Royal University.

In Germany there are twenty-two universities; in France, under recent legislation, fifteen; in Italy, twenty-one. It is difficult to give the number in the United States, because it is clear, from the tables given in the Report of the Commissioner of Education, that some colleges are more important than some universities, and both give the degree of Ph.D. But of universities in title we have 134. Among these, there are forty-six with more than fifty professors and instructors, and thirteen with more than 150. I will take that figure.

Suppose we consider the United States and Germany our chief commercial competitors, and apply the Admiralty principle. We should require, allowing for population, eight additional universities at the very lowest estimate.

We see, then, that instead of having universities equaling in number those of two of our chief competitors together, they are by no means equal to those of either of them singly.

After this statement of the facts, any one who has belief in the importance of higher education will have no difficulty in understanding the origin of the present condition of British industry and its constant decline, first in one direction and then in another, since the tremendous efforts made in the United States and Germany began to take effect.

If, indeed, there be anything wrong about the comparison, the error can only arise from one of two sources; either the Admiralty is thoughtlessly and wastefully spending money, or there is no connection whatever between the higher intelligence and the prosperity of a nation. I have already referred to the views of Mr. Chamberlain and Lord Rosebery on this point; we know what Mr. Chamberlain has done at Birmingham; we know the strenuous efforts made by the commercial leaders of Manchester and Liverpool; we know, also, the opinion of men of science.

If while we spend so freely to maintain our sea-power our export of manufactured articles is relatively reduced because our competitors beat us in the markets of the world, what is the end of the vista thus opened up to us? A Navy growing stronger every year and requiring larger votes to guard our commerce and communications, and a vanishing quantity of commerce to guard—a reduced national income to meet an increasing taxation!

The pity is that our government has considered sea-power alone; that while so completely guarding our commerce it has given no thought to one of the main conditions on which its production and increase depend: a glance could have shown that other countries were building universities even faster than they were building battleships; were, in fact, considering brain-power first and sea-power afterwards.

Surely it is my duty as your president to point out the danger ahead if such ignoring of the true situation should be allowed to con-

tinue. May I express a hope that at last, in Mr. Chamberlain's words, 'the time is coming when governments will give more attention to this matter'?

The comparison shows that we want eight new universities, some of which, of course, will be colleges promoted to university rank and fitted to carry on university work. Three of them are already named: Manchester, Liverpool, Leeds.

Let us take this number and deal with it on the battleship condition, although a modern university on American or German models will cost more to build than a battleship.

If our present university shortage be dealt with on battleship conditions, to correct it we should expend *at least* 8,000,000*l.* for new construction, and for the pay-sheet we should have to provide ($8 \times 50{,}000l.$) 400,000*l.* yearly for personnel and up-keep, for it is of no use to build either ships or universities without manning them. Let us say, roughly, capitalizing the yearly payment at 2½ per cent., 24,000,000*l.*

At this stage, it is important to inquire whether this sum, arrived at by analogy merely, has any relation to our real university needs.

I have spent a year in making inquiries, as full as I could make them, of friends conversant with the real present needs of each of the universities old and new; I have obtained statistics which would fill a volume, and personally I believe that this sum at least is required to bring our university system up to anything like the level which is insisted upon both in the United States and in Germany. Even Oxford, our oldest university, will still continue to be a mere bundle of colleges, unless three millions are provided to enable the university properly so-called to take her place among her sisters of the modern world; and Sir Oliver Lodge, the principal of our very youngest university, Birmingham, has shown in detail how five millions can be usefully and properly applied in that one locality, to utilize for the good of the nation the enthusiasm and scientific capacity which are only waiting for adequate opportunity of development.

How is this money to be raised? I reply without hesitation, *duplicate the Navy Bill of* 1888–9; do at once for brain-power what we so successfully did then for sea-power.

Let 24,000,000*l.* be set apart from one asset, our national wealth, to increase the other, brain-power. Let it be assigned and borrowed as it is wanted; there will be a capital sum for new buildings to be erected in the next five or ten years, the interest of the remainder to go towards increased annual endowments.

There need be no difficulty about allocating money to the various institutions. Let each university make up its mind as to which rank of the German universities it wishes to emulate. When this claim has been agreed to, the sums necessary to provide the buildings and teach-

ing staff of that class of university should be granted without demur.

It is the case of battleships over again, and money need not be spent more freely in one case than in the other.

Let me at once say that this sum is not to be regarded as practically gone when spent, as in the case of a short-lived ironclad. *It is a loan* which will bear a high rate of interest. This is not my opinion merely; it is the opinion of those concerned in great industrial enterprises and fully alive to the origin and effects of the present condition of things.

I have been careful to point out that the statement that our industries are suffering from our relative neglect of science does not rest on my authority. But if this be true, then if our annual production is less by only two millions than it might have been, having two millions less to divide would be equivalent to our having forty or fifty millions less capital than we should have had if we had been more scientific.

Sir John Brunner, in a speech connected with the Liverpool School of Tropical Medicine, stated recently that if we as a nation were now to borrow ten millions of money in order to help science by putting up buildings and endowing professors, we should get the money back in the course of a generation a hundredfold. He added that there was no better investment for a business man than the encouragement of science, and that every penny he possessed had come from the application of science to commerce.

According to Sir Robert Giffen, the United Kingdom as a going concern was in 1901 worth 16,000,000,000*l.*

Were we to put aside 24,000,000*l.* for gradually organizing, building and endowing new universities, and making the existing ones more efficient, we should still be worth 15,976,000,000*l.*, a property well worth defending by all the means, and chief among these brain-power, we can command. If it be held that this, or anything like it, is too great a price to pay for correcting past carelessness or stupidity, the reply is that the 120,000,000*l.* recently spent on the navy, a sum five times greater, has been spent to correct a sleepy blunder, not one whit more inimical to the future welfare of our country than that which has brought about our present educational position. We had not sufficiently recognized what other nations had done in the way of ship building, just as until now we have not recognized what they have been doing in university building.

Further, I am told that the sum of 24,000,000*l.* is less than half the amount by which Germany is yearly enriched by having improved upon our chemical industries, owing to our lack of scientific training. Many other industries have been attacked in the same way since, but taking this one instance alone, if we had spent this money fifty years ago, when the Prince Consort first called attention to our backwardness,

the nation would now be much richer than it is, and would have much less to fear from competition.

Suppose we were to set about putting our educational house in order, so as to secure a higher quality and greater quantity of brain-power, it would not be the first time in history that this has been done. Both Prussia after Jena and France after Sedan acted on the view:

> "When land is gone and money spent,
> Then learning is most excellent."

After Jena, which left Prussia a 'bleeding and lacerated mass,' the King and his wise counselors, among them men who had gained knowledge from Kant, determined, as they put it, 'to supply the loss of territory by intellectual effort.'

What did they do? In spite of universal poverty, three universities, to say nothing of observatories and other institutions, were at once founded, secondary education was developed, and in a few years the mental resources were so well looked after that Lord Palmerston defined the kingdom in question as 'a country of damned professors.'

After Sedan, a battle, as Moltke told us, 'won by the school-master,' France made even more strenuous efforts. The old University of France, with its 'academies' in various places, was replaced by fifteen independent universities, in all of which are faculties of letters, sciences, law and medicine.

The development of the University of Paris has been truly marvelous. In 1897–8, there were 12,000 students, and the cost was 200,000*l.* a year.

But even more wonderful than these examples is the 'intellectual effort' made by Japan, not after a war, but to prepare for one.

The question is, shall we wait for a disaster and then imitate Prussia and France? or shall we follow Japan, and thoroughly prepare by 'intellectual effort' for the industrial struggle which lies before us?

Such an effort seems to me to be the first thing any national or imperial scientific organization should endeavor to bring about.

SHORTER ARTICLES AND DISCUSSION.

THE AURORA BOREALIS OF AUGUST 21.

To THE EDITOR: I have been much interested in the account given by Dr. A. F. A. King of the unusual aurora observed by him on the twenty-first of August at York Harbor, Maine (POPULAR SCIENCE MONTHLY, Vol. LXIII., pp. 563–4), because I also observed it the same evening from a point near Baddeck, Cape Breton Island, Nova Scotia.

My attention was called to the display about 8:45 P.M., Halifax time (this would be about 7:45 P.M. by eastern standard time, which I presume is the time used by Dr. King). There was then nothing unusual about the aurora.

I went out of doors especially for the purpose of ascertaining whether any auroral arch was visible extending from east to west across the zenith; for I observed such a phenomenon here two or three years ago (but without the comet-like appendages described by Dr. King) and have been on the lookout since for its reappearance. Certainly no such arch was visible here at 8:45 P.M. on August 21, and the whole display seemed then to be on the wane. Shortly after 9:00 P.M. only a diffused glow remained in the northern sky above a bank of auroral cloud.

During the course of the night I observed the aurora occasionally to see if there was any change, but noticed nothing unusual until 12:45. The arch might have appeared between 9:00 P.M. and 12:45 without my noticing it, as intervals of at least an hour separated my observations. I can say positively that it did not appear between 12:45 and 2:30 A.M., as I was out of doors continuously watching the sky during that time. From 9:00 P.M. till after midnight I noticed nothing more than the usual faint glow in the north; but happening to glance out of the window at 12:45 I was startled by the tremendous activity then displayed. The maximum was reached about 1:00 A.M., and by 2:00 A.M. the display was practically over. At 2:30 A.M., I returned indoors and made a record of my observations, from which I quote the following extract:

. . . Looking out about 12:45 (a quarter to one A. M., Saturday) great activity was manifest. The whole northern sky was ablaze, pulsations of light streamed upwards from the horizon as though light phosphorescent clouds were being blown along by a hurricane. Upon going out I found that faint auroral clouds covered the whole sky even to the south. Faint pulsations of light in the south appeared to be streaming north while the northern streamers streamed south.

Observing attentively, there seemed to be a luminous streaming upwards from the horizon all around, converging—not at the *zenith*—but at a point of the sky which I should think would be opposite the sun. I was powerfully impressed by the idea that these were parallel rays directed away from the sun, rendered convergent by perspective.

At the point opposite the sun a considerable space—roughly circular in outline—seemed to be generally free from luminous cloud effects, except when a suffused glow would come and cover the space—a momentary glow without stream effect. Towards the circular space the stream effects were centrally directed all round, being most marked in the northern and northwestern sky, where the stream effects were vivid—luminous pulsations like light smoke driven by a hurricane. The stream effects were much less marked in the western, southern and eastern sky. Light glows would appear, but only by at-

tention could the stream effects be distinguished. I am certain, however, that they were there and that the direction was upwards towards this anti-helial (?) position everywhere.

The appearances noted were highly suggestive of luminous matter of some sort streaming past the earth on all sides with tremendous velocity in a direction away from the sun—the parallel streams being rendered apparently convergent by perspective.

The aurora, however, is believed to be a strictly terrestrial phenomenon in the nature of an electrical discharge in the higher regions of the atmosphere; although good grounds exist for supposing that there is some intimate connection between great auroral displays on the earth and disturbances going on in the sun.

In this connection it would be interesting to know where Borelli's comet was at the time. It was then rapidly nearing its closest approach to the sun.

ALEXANDER GRAHAM BELL.

BEINN BHREAGH, NEAR BADDECK, NOVA SCOTIA, September 26, 1903.

MR. COOK ON EVOLUTION, CYTOLOGY, AND MENDEL'S LAWS.

TO THE EDITOR: Owing to my absence in Europe, Mr. O. F. Cook's article, published under the above title in the July number of the POPULAR SCIENCE MONTHLY, has only now come to my attention. Mr. Cook's somewhat drastic criticism of the suggestion regarding Mendelian inheritance, made in my article in the issue of *Science* for December 19, 1902, takes a prominent place in his essay and relates to a question of wide biological interest. I, therefore, ask space to point out that he failed to grasp the nature of the suggestion; and unfortunately the confusion was worse confounded by his misquotation, of course unintentional, of my own statement in such a way as to make me seem to commit the very error that is the object of his criticism, though I myself had expressly warned against such an error in a paper read before the Washington meeting of the American Association last December!

Mr. Cook's objection to the suggestion, as he understood it and as he quoted it, is perfectly correct, and the man of straw thus set up by his own hand is properly overthrown. Assuredly, to maintain that the reducing division in the maturation of the germ-cells 'leads to the separation of paternal and maternal elements and their ultimate isolation' *as* 'separate germ-cells' (this as quoted by Mr. Cook, italics mine) involves, as he points out, the *reductio ad absurdum* that the individual could not show characters individually traceable to more than two grandparents; for this form of statement implies that purely paternal or maternal *groups* of chromosomes are separated by the division, to be isolated as such in the gametes, the latter being thus rendered pure in respect to parentage. But this, of course, was not my meaning, nor was it what I said. Mr. Cook failed to perceive that my statement referred, not to the parental *groups*, but to the members of the *individual pairs* of paternal and maternal chromosomes. What I said was the isolation of the paternal and maternal elements, not '*as*' but '*in*' separate germ-cells; and the elements thus separated from each other were specifically designated as 'the members of each pair.' I regret that Mr. Cook did not read with greater attention; for my phraseology was carefully chosen, the untenability of the view which is erroneously ascribed to me having been clearly pointed out by Mr. Sutton when he first brought his suggestion to my attention, and since fully considered by him in an article on 'The Chromosomes in Heredity' published in the *Biological Bulletin* for last April. It is only fair to add that since Mr. Cook accuses me, as he does Mr. Cannon, of a failure to understand the Mendelian

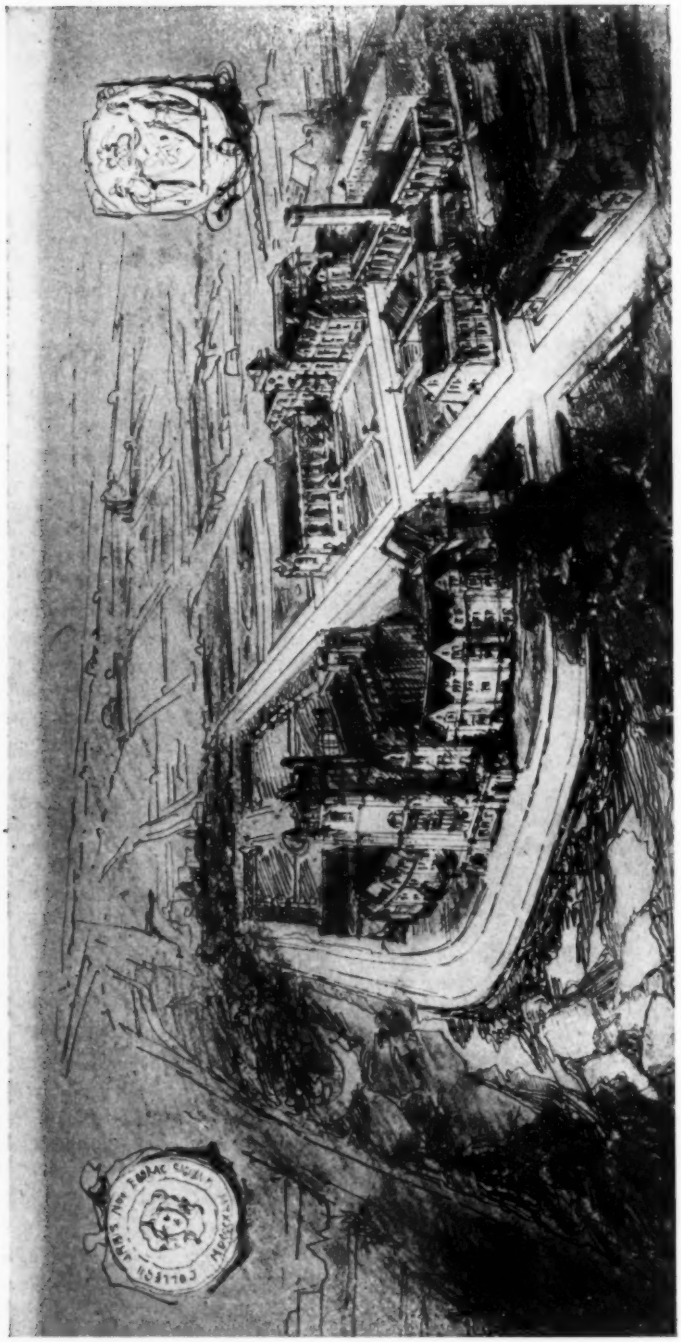
principle, it is probable that his misinterpretation arose from the association in his mind of my communication with Mr. Cannon's paper on 'A Cytological Basis of Mendel's Law,' where unfortunately the error in question was not avoided. This paper I first saw after its publication.

In point of fact the cytological evidence on which Sutton based his suggestion leaves quite undecided the question whether any definite order is followed in the grouping of the chromosome-pairs in the equatorial plate, and places no obstacle in the way of assuming that their position is a matter of chance, *i. e.*, that paternal and maternal chromosomes may lie indifferently toward either pole, and that consequently all combinations of paternal and maternal chromosomes may be produced in the gametes. To employ Sutton's graphic illustration: if the number of chromosomes be taken as 8 and designated as A, a, B, b, C, c, D, d (large letters denoting paternal chromosomes and small ones the corresponding maternal), the chromosome-pairs in the equatorial plate might, so far as the cytological evidence shows, present any or all the groupings $\frac{ABCD}{abcd}$, $\frac{abCD}{ABcd}$, $\frac{aBcD}{AbCd}$, and so on, which gives a possibility of 16 different combinations in the gametes and of 256 in the zygotes or offspring. If the number of chromosomes be 24 (a very common number), the number of possible combinations in the gametes becomes more than 4,000 and in the zygotes nearly 17,000,000 (Sutton). The assumption is, therefore, in full harmony with the fact that offspring may show many different combinations of characters individually traceable to four grandparents or a greater number of more remote ancestors.

Despite the immense range of mixed variation and inheritance thus permitted under the assumption, a point of real difficulty, not touched on by Mr. Cook, is the relatively small number of chromosomes as compared with that of transmissible characters; for if the chromosome-hypothesis, as developed by Sutton, be valid, it would seem to follow that each chromosome stands not for one, but for many, characters, and these should form a coherent group in inheritance. Coherent groups of associated characters have, however, been recognized by many observers, including Mendel himself; and in this direction definite evidence for or against the chromosome hypothesis may perhaps be obtained by the comparative study of variation in nearly related species that differ in the number of chromosomes, though this presents a problem of great complexity. Regarding cases of non-conformity to the so-called Mendelian law or principle, Sutton has endeavored to show that they do not invalidate the suggestions given by the cytological work of himself, Montgomery, Cannon and others. They sufficiently indicate, however, that these suggestions do not yet afford a full or positive explanation, but only, in my own former phrase, give a 'clue' which awaits further development and test. It is entirely possible that the clue may prove false, yet even so it may serve to illustrate that 'fertility of false theories' to which Mr. Cook pays his tribute. In the meantime it is to be regretted that a biologist of Mr. Cook's standing should give currency to the statement that 'The notion that heredity, variation and evolution are the functions of special organs or mechanisms of cells has no ascertained basis of fact' (*l. c.*, p. 222). This 'notion' may be true or false, but such an utterance will be truly surprising to any one having some degree of acquaintance with the literature of embryology and cytology.

EDMUND B. WILSON.

COLUMBIA UNIVERSITY,
September 24, 1903.



BIRD'S-EYE VIEW OF THE BUILDINGS OF THE COLLEGE OF THE CITY OF NEW YORK.

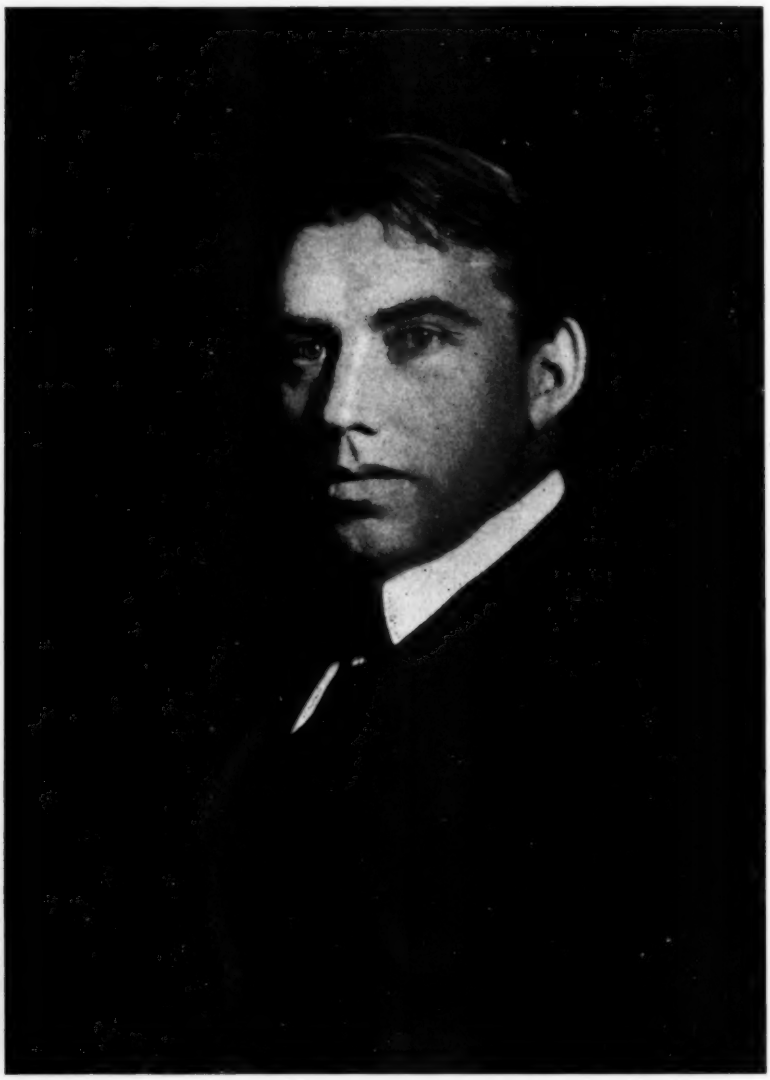
THE PROGRESS OF SCIENCE.

THE COLLEGE OF THE CITY OF NEW YORK.

SINCE 1848 the College of the City of New York and its predecessor, the Free Academy, have carried forward an educational work the importance of which is scarcely appreciated. Yale and Princeton are household words, where the existence of the City College is unknown. Yet the college has rivaled the more prominent institutions both in numbers of students and in the efficiency of the courses of instruction. From the point of view of this journal, it is sufficient to note that at least two members of the National Academy of Sciences are graduates of the college, and that the only living ex-president of the academy was formerly one of its professors. There is reason to believe that September 29, when a new president was installed and the corner-stone of the new buildings was laid, will mark an epoch in the history of the institution, and that it will become one of the chief centers for the educational progress of the future.

The ceremonies of installation and dedication were themselves imposing. Those who hold that academic processions, gowns and the like are somewhat out of place in a modern democratic community were at least given the pleasure of seeing gowns handed out with an even hand to all, whether or not they possessed academic degrees. The fact of special interest was the representation on the program of republicans and democrats, of protestants, catholics and jews, all uniting in the service of the college without regard to political or denominational differences. Mayor Low spoke immediately after Mr. Shepard, his rival in the contest for the mayorality two years ago, and Ex-President Cleveland followed Senator Depew. Other speeches were made by Governor Odell, the presidents of Columbia, Cornell, Yale and the Johns Hopkins Universities, and by representatives of the trustees, faculty, alumni and students of the college. The new president of the college made an admirable inaugural address, showing full appreciation of the problems before the college and the city.

Dr. John Huston Finley was offered the presidency of the college after a careful search had been made through the whole country for the best attainable man. That one born in Illinois, at the time professor in a university in another state, regarding whose political or religious affiliations no questions were asked, was chosen, shows that municipal institutions can be conducted without local or partisan prejudice. General Webb, who retires from the presidency at the age of sixty-seven years, held the office for twenty-three years. A graduate of West Point and a general in the regular army, he possessed valuable qualifications for the office, but he was not an educational leader. The students were well trained and well drilled, but instructors were assigned to teach subjects with which they were not familiar and investigation was not sufficiently encouraged. The college did not take an important place in the educational and scientific progress of the country. Dr. Finley has the vigorous personality and has had the training and experience fitting him for a college presidency—one of the most responsible and influential, and at the same time one of the most complicated and difficult of positions. As a boy he worked on a farm and in a



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DR. JOHN HUSTON FINLEY, PRESIDENT OF THE COLLEGE OF THE CITY OF NEW YORK.

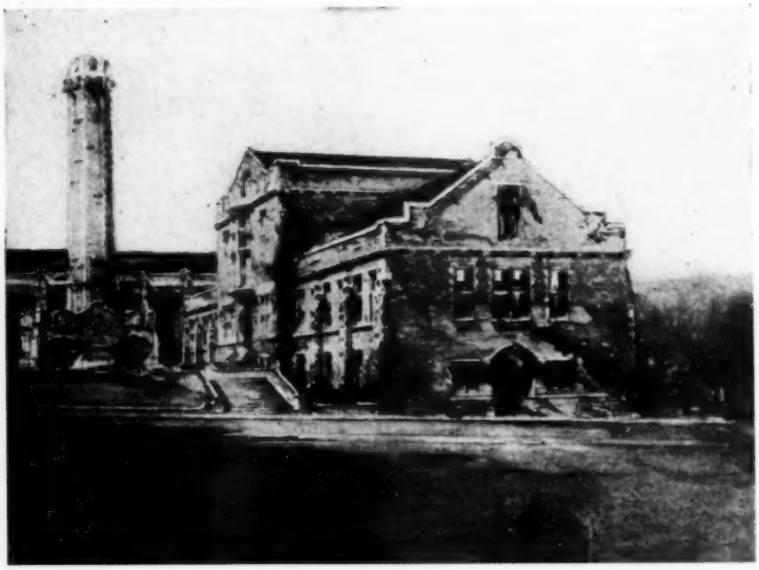
ST. NICHOLAS TERRACE FACADE — MAIN BUILDING.

printing office. He was called to the presidency of Knox College five years after graduating from it. He had pursued graduate studies at the Johns Hopkins University and had been secretary of the State Charities Aid Association of New York. He resigned the presidency of Knox College after seven years of useful service, and was engaged on the editorial staff of *Harper's Weekly* and *McClure's Magazine*. In 1900 he was called to the professorship of politics at Princeton University. And this wide experience he has gained before the age of forty. From his administration of the college much may be expected.

The new buildings of the college, some illustrations of which are here shown, are worthy not only of the work that the college has done, but also of what may be expected from it. They stand on rising ground a mile north of Columbia University, occupy-

GYMNASIUM AND SUB-FRESHMAN BUILDING.

ing a somewhat similar site, but not so completely shut in by apartment houses. Gothic architecture, like academic gowns, seems to belong to the past rather than to the future, but a traditional environment carries with it much that is good, and there is perhaps more danger in innovation than in imitation. The architect, Mr. Geo. B. Post, has certainly fitted the buildings admirably to the site and united them to a picturesque whole. It is unfortunate that the modern college and the scientific laboratory have not developed a significant architectual form, but it is useless to complain of the inevitable.



CHEMICAL AND MECHANICAL ARTS BUILDINGS FROM COLLEGE GROUNDS.

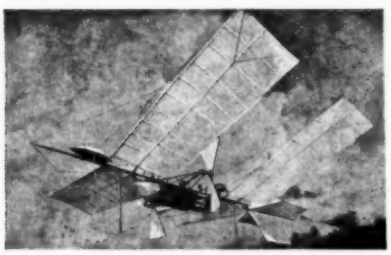
It has been indicated that the College of the City of New York may become one of the storm-centers of educational development. In spite of remarks made at the installation ceremonies by several of the speakers, including university presidents, the New York City College is not unique. There are somewhat similar institutions in Philadelphia and Baltimore, and Cincinnati has a municipal university. But the New York institution, coordinate with the great state universities, must lead the way. Here all the questions of the relation of the college to the high school and to the university, of liberal to technical studies, of higher education to the state, of public to semi-private and semi-religious institutions, will become pressing. We do not hesitate to express the opinion that the maintenance of education is as completely a public duty as the maintenance of the courts or of the army, that higher education should no more be left to private initiative than elementary education, and that ultimately all the educational and scientific institutions of New York City will be unified under the control of the people of the city.

AERIAL NAVIGATION.

READERS of THE POPULAR SCIENCE MONTHLY may naturally expect to find here more or less authoritative statements in regard to scientific matters

exploited in the newspapers. One of the subjects that has attracted particular attention recently is the aerodrome of Dr. S. P. Langley, secretary of the Smithsonian Institution. The somewhat sensational character of the attempt to fly and the secrecy with which the proceedings are surrounded have naturally excited public curiosity, and the newspapers have found the failure of the machines a good opportunity for jokes, so that we read of 'airships as submarines' and the like.

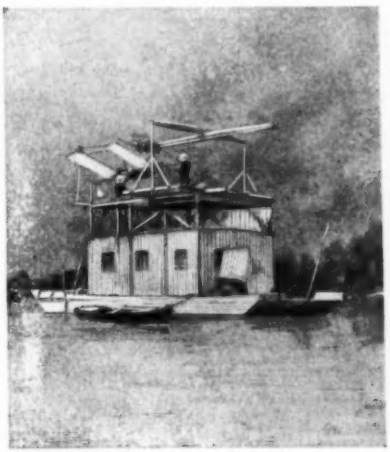
Dr. Langley has carried forward important researches in aerodynamics, and has done more than any one else toward constructing an aeroplane that would fly. After numerous experiments and failures a machine was launched in 1896 that stayed in the air from one to two minutes. We reproduce from the 'Report' of the Smithsonian Institution for 1900, two pictures of this aerodrome, one an imaginary sketch, the other from a photograph taken by Dr. A. Graham Bell. The total length was about 16 feet and the width between the wings about 12 feet. The weight was about 30 pounds, of which one fourth was represented by the machinery, the engines, which could supply one to one and a half horse-power, weighing 26



THE AERODROME AS IT MIGHT APPEAR IN THE AIR.

ounces, and the boiler about 5 pounds.

Dr. Langley has not published a scientific account of his work, but contributed a popular article to *McClure's Magazine* for June, 1897, which he reprinted in the 'Report' of the Smithsonian Institution for 1900, and to this our readers may refer. It appears to us that Dr. Langley takes rather too little credit for his work on aerodynamics and rather too much



THE AERODROME. READY FOR LAUNCHING.

for the practical success of his flying machine. Hundreds of patents for aeroplanes had been taken previously, and toys had been constructed that would fly. The Langley aerodrome was not steered, nor tried in a breeze, nor able to carry any weight, nor kept in the air as long as two minutes. This record has of course been much surpassed by dirigible balloons and perhaps by artificial flight. Aeroplanes can doubtless be made to fly; as Lord Rayleigh, quoting Mr. Maxim, has said, 'it is mainly a question of some time and much money.' Aeroplanes will probably be used for military purposes and for adventure, but not for the ordinary uses of transportation and commerce. Dr. Langley seems to claim too much when he writes in a popular magazine that he has demonstrated the practicability of mechanical flight and that 'the great universal highway overhead is now soon to be opened'; that aerodromes 'may be built to remain days in the

air,' 'to travel at speeds higher than any with which we are familiar.'

The secretary of the Smithsonian Institution should be the representative of American science and should be extremely careful not to do anything that may lend itself to an interpretation that will bring injury on the scientific work of the government or of the country. Dr. Langley has stated that for 'the commercial and practical development of the idea it is probable that the world may look to others.' We think that it would have been better if the secretary of the Smithsonian Institution had adhered to this resolution and had not spent large sums on secret experiments for the War Department. He could have placed his scientific knowledge at the disposal of army officers and expert mechanicians, and this would have been better than to attempt to become an inventor in a field where success is doubtful and where failure is likely to bring discredit, however undeserved, on scientific work.

SCIENTIFIC ITEMS.

PROFESSOR ALEXANDER BAIN, for many years professor of logic in the University of Aberdeen, died on September 17, at the age of eighty-five years. Dr. Bain was the author of an important series of books on psychology, logic and English. His works on 'The Senses and the Intellect,' in 1855, and 'The Emotions and the Will,' in 1859, in many ways laid the foundations of modern scientific psychology.

DR. W. A. NOYES, of the Rose Polytechnic Institute, has accepted the position of chemist in the National Bureau of Standards.—Professor J. Mark Baldwin, of Princeton University, has been called to organize a graduate department of philosophy and psychology at the Johns Hopkins University.—Dr. T. H. Montgomery, Jr., assistant professor of zoology at the University of Pennsylvania, has been appointed to the professorship of zoology in the University of Texas, vacant by the removal of Professor W. M. Wheeler to the American Museum of Natural History. Dr. Herbert S. Jennings, assistant professor of zoology at the University of Michigan, and now at Naples, has been called to the assistant professorship of zoology at the University of Pennsylvania.

MR. ROBERT E. PEARY has been given three years' leave of absence from the navy to continue his Arctic explorations. His plan contemplates the construction of a strong wooden ship with powerful machinery, in which he will sail next July to Cape Sabine and, after establishing a sub-base there, force his way northward to the northern shore of Grant Land, where he will spend the winter with a colony of Whale Sound Esquimaux, who will be taken there by him from their homes further south. This winter base will be at or in the vicinity of Cape Columbia or Cape Joseph Henry, situated about the 82d degree of north latitude.

THE new medical buildings and laboratories of Toronto University were officially opened on October 1. The opening address was given by Professor Charles S. Sherrington, of Liverpool. Speeches were made by representatives of various institutions, and an address in the evening was made by Professor William Osler, of the Johns Hopkins University. A special convocation was held on October 2, at which the following visitors received the honorary degree of LL.D. from the university: William Williams Keen, Jefferson Medical College, Philadelphia; William Henry Welch, Johns Hopkins University; William Osler, Johns Hopkins University; Russell Henry Chittenden, Yale University; Charles S. Sherrington, University of Liverpool; Henry Pickering Bowditch, Harvard University.